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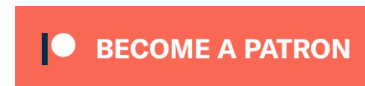
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Machine Gun Notes

For Official Use Only

NOTE—The following
and tactical handling
a complete discussion
existing War Department
guide to officers and
gun units.

E. L. Dowd
FOR OFFICIAL USE ONLY

Machine Gun Notes

Compiled at the
Divisional School of Arms
for the use of Officers and Non-Commissioned
Officers of the 86th Division, N. A.

June 1, 1918

NOTE—The following notes on the mechanical, practical and tactical handling of machine guns are not intended to be a complete discussion of the subject, or to conflict with any existing War Department publications. They are issued as a guide to officers and non-commissioned officers of machine gun units.

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INTRODUCTION TO GUN.

Before the war it took a long time to develop an efficient Machine Gun Instructor, but due to urgent circumstances it has been found necessary to eliminate all but those things which are absolutely necessary, to turn out gunners who can perform their duties well in a comparatively short time. Nomenclature is eliminated and replaced by a combination of demonstration and description.

The initial work is done on the 1,000 inch range. No elaborate range or target is necessary, but care should be taken in selecting the site of a range. To avoid the danger of ricochet, the line of sight should be depressed. A bank of soft earth ten to fifteen feet high should form the background of the target. The earth should be ten to twelve feet in thickness to be absolutely safe, although the bullet will only penetrate five or six feet of solid earth.

The first introduction of a new class to the machine gun:

1. Name of gun; weight; principle.
2. How fed; by belt containing 250 rounds—fed into feed box.
3. How to load the gun.
4. How to fire the gun.

Demonstrate fixed, searching, and distributed fire. Call attention to action of roller handle.

Allow students to fire a few rounds to allay any fear of the gun, and to become accustomed to its "feel."

Class should be taught by eye, simple language used, with few technical terms. Progress should be made by slow degrees.

In the first introduction to the gun the following points should be observed.

The name—automatic—fires 500 rounds per minute—cooled by water in a water jacket holding $7\frac{1}{2}$ pints of water. Show how gun operates by removing the sleeve and recoil spring and opening the rear cover. Describe belt and how cartridges are fed into the gun.

CARE AND CLEANING.

1. Responsibility,
To Government.
2. Importance of care and cleaning.
Fire power decreased.
Short life of gun.
3. Kit required for teaching:
Gun, tripod, ammunition box, belt, dummies, cleaning rod, wire gauze, patches, old linen, lubricating oil, paraffin, turpentine, mirror, spring balance, muzzle protector, **boiling** water.
4. General remarks.
 - (a) Guns should be examined daily after cleaning.
 - (b) Protected from sand in dusty countries.
(Canvas bag.)
 - (c) Do not damage gun by careless handling.
 - (d) Do not lay gun down in the mud.
 - (e) Never keep main spring compressed.
 - (f) See that brushes in handle block reservoir are securely fastened.
 - (g) Never play with roller handle when lock is out of gun.

5. Frosty weather.
Oil mechanism slightly. Try to prevent water from freezing. Add 20 per cent. glycerine. May use 50 per cent., but not more than five pints of fluid in this case.

6. Gas attacks.

- (a) Keep gun firing.
- (b) Cover gun with water-proof, and close ammunition boxes.
- (c) Operate recoiling parts by hand.
- (d) After gas, clean as soon as possible.
- (e) After gas, ammunition should be oiled and wiped off.
- (f) Heavy oil will prevent gas corrosion for twelve hours.

7. Tripod.

Do not damage or bend jamming handles. Do not break chains. Do not damage elevating gear and keep it tight. Do not damage traversing clamp. Keep teeth on legs and track clean. Overhaul frequently and keep clean.

8. Belts.

Examine belts daily for following points:

- (a) Clean.
- (b) Not torn.
- (c) Brass strips not bent or broken.
- (d) Packed correctly in boxes and not forced in.
- (e) Free from oil and moisture.
- (f) New belts plugged before using.
- (g) To clean belts: Soak for two hours in boiling water containing one part soda, three parts soft soap and ten parts water. Scrubbed, dried and plugged.

9. Belt boxes.

Inspected frequently. Metal boxes should not be dented. Interior of boxes clean. Exterior free from mud.

10. Ammunition.

- (a) Not subjected to extreme heat.
- (b) Keep clean and dry.
- (c) Inspected daily and all rounds turned.
- (d) Free from grit.
- (e) **Must never be oiled.**

11. History sheet.

- (a) Number of rounds fired.
- (b) Breakages.
- (c) Peculiarities.
- (d) Stoppages.
- (e) Cause of above.
- (f) Remedy applied.
- (g) Adjustment.

Sheet kept in gun box.

12. Barrels.

Always clean.

NOTE: Teach packing.

13. Wear in barrels.

- (a) Friction of bullet.
- (b) Heat from explosion.
- (c) Cleaning—Use gauze but occasionally.

14. Rounds fired before gun is unserviceable.

If fired in short bursts over an extended period will last 60,000 rounds or more per barrel. If 10,000 rounds were fired in a day it probably would not last more than 20,000 rounds.

15. A high polish in the bore will safeguard against rust.

16. Kinds of fouling.

Superficial—The deposit in the bore of solid products of the powder and primer.

Internal—Caused by forcing the products of the explosion into the pores of the barrel.

Metallic—Portion of the cupro-nickel of the envelope of the bullet left on bore.

17. Daily cleaning.

Wipe all parts with a slightly oiled cloth—gun should not be stripped every day. Turpentine used to clean any parts of dirt, grit and corroded oil. After cleaning, dry and oil slightly. Too much oil collects dirt. Work recoiling parts to distribute oil.

18. How to teach daily cleaning.

Instructor demonstrates cleaning of exterior, hanging the lock and oiling the working parts. Explain fully how to remove anything that might be clogged in the mechanism. How to dry and oil.

Ask questions concerning daily cleaning.

19. Weekly cleaning.

Fully stripped and cleaned every week. Overhauled for missing, burred or broken parts. Remove oil from bore and dry for inspection. Dry for inspection and oil after. Importance cannot be overestimated.

20. Use of cleaning rod.

- (a) Remove muzzle attachment and barrel disk.
- (b) Raise rear cover.
- (c) Lift out lock and rest it on front of rear cover.
- (d) Insert an oily patch in each eyelet of cleaning rod. Demonstrate how to oil cloth.
- (e) Insert rod in muzzle end and work back and forth.
- (f) Dry bore.
- (g) After inspection leave bore slightly oily.
(Don't throw old patches away.)

Pack wire gauze in S shape without bulging. Don't use double pull through unless necessary. "Clean before firing" means slightly oil all working parts.

21. Cleaning after.

Fully and immediately.

Cleans better when warm. Remove internal fouling with six or seven pints of boiling water. Dry and oil. Clean bore daily. Remove fouling on barrel discs and front disc. Scrape with screw driver and rub with emery cloth. Do not chisel.

NOTES.

- 1. Don't drag gun and tripod through the mud.
- 2. Barrel disc or any threaded part see that threaded parts engage properly.
- 3. Use oil on disc and muzzle cup after firing.
- 4. Clean well when returning to gun shed or shelter.
- 5. Barrel should be cleaned daily for nine days after firing.
- 6. Insist on proper care of lock.
- 7. In sandy or dusty countries use as little oil as possible.
- 8. Never have both covers up at the same time.
- 9. Light film of oil on outside and inside of barrel.

A FEW DON'TS FOR THE VICKERS.

- 1. Don't pull on chains.
- 2. Always use correct tools.
- 3. Always see that screws are fully home and tight.
- 4. Never throw covers back.

5. Put the feed box in correctly.
6. When closing front cover always have the catch up.
7. Never use direct hammer blows on any part of the gun.
8. Lock must be in properly.
9. Always pull back roller handle before opening the rear cover.
10. The life of a machine gun depends upon how it is handled.
11. No unnecessary stripping to be undertaken.
12. See that pins have feathers.
13. Keep elevating screws clean.
14. See that jamming handles are tight at all times.
15. Keep pintle and socket clean at all times.

STRIPPING.

The kit required for stripping the gun:

Gun, tripod, ammunition box, belt, dummies, tool box, complete, water-proof sheet, water box.

TO CHANGE A BARREL.

Unload and remove the lock. Get spanner and remove sleeve. Remove barrel disc. Remove water plug from the rear filling hole. Remove feed box. Remove recoil spring and box. Remove fusee and links. Raise rear cover and remove handle block pin. Lower handle block. Remove roller bracket and left filling piece. Depress the gun. Draw recoiling parts to the rear. Remove left and right recoil plates. Remove barrel. (Note: Teach method to retain water.) Assemble in the reverse order.

TO STRIP THE LOCK.

1. Cock the lock.
2. Remove side lever inner fixing pin.
3. Remove side lever outer fixing pin.
4. Remove side lever.
5. Remove lifting lever.
6. Remove carrier.
7. Remove tumbler, fixing pin.
8. Remove tumbler.
9. Fire lock to release the main spring.
10. Remove hand sear fixing pin.
11. Remove hand sear.
12. Remove main spring.
13. Remove firing pin.
14. Remove safety sear.
15. No. 5 punch or handle block pin to strip.

TO ASSEMBLE LOCK.

1. Insert safety sear.
2. Insert firing pin flush with case.
3. Insert tumbler and pin.
4. Insert hand sear and pin.
5. Put on carrier.
6. Put on left lifting lever.
7. Put on right lifting lever.
8. Put on side levers.
9. Outer and inner side lever pins.
10. Insert main spring after placing the lock on a firm base, depressing safety sear with the side lever, pushing hand sear to rear and pressing down on the tail of the tumbler (all tails down). Then test lock.

MECHANISM (VICKERS.)

1. Sequence of Instruction in Mechanism:

- (1) How to load.
- (2) How to fire.
- (3) How to unload.
- (4) Action on recoil.
- (5) First action in feed box.
- (6) Backward rotation of the crank.
- (7) Second action in the feed box.
- (8) Outside and backward action of the lock.
- (9) Inside or cocking action of the lock.
- (10) Action of recoil spring.
- (11) Forward movement of the lock.
- (12) Firing the first shot.
- (13) Subsequent shots.
- (14) Action on releasing pressure on thumb piece.
- (15) Single shot mechanism.

Kit Required:

- (1) Gun with instructional lock and tripod.
- (2) Belt in belt box.
- (3) Dummy cartridges.
- (4) An empty case.
- (5) Spare lock and spare feed box.
- (6) Instructional diagrams.

NOTE: Gun must be correctly set up and instruction carried out as follows:

- (1) Preparation of gun.
- (2) Demonstrate what you are about to teach.
- (3) Explain what you have demonstrated.
- (4) Immitation.
- (5) Interrogation.

HOW TO LOAD.

- (1) Pass the tag end of the belt through feed box.
- (2) With right hand pull roller handle on to roller.
- (3) With left hand pull belt to left front.
- (4) Let go roller handle. The first cartridge will be gripped in the carrier. Repeat the above and the carrier will grip a live round in the chamber and a live round in the feed box. The gun is ready to fire.

MECHANISM.

How Taught:

- (a) Demonstrate loading.
- (b) Explain:
 - (1) Tag end of belt.
 - (2) Roller handle. Three reasons.
 - (3) Belt to left front.
 - (4) Let go roller handle.
 - (5) Repeat above.
 - (6) Cartridge in chamber.
 - (7) Cartridge on carrier.
 - (8) Gun ready to fire.
- (c) Squad practices.
- (d) Ask questions.

2. How to Fire.

On raising the safety catch and pressing the thumb piece the gun will fire automatically until pressure is released or until all the

ammunition in the belt is fired. In the first case the lock will be home and the carrier will be gripping a live cartridge in the feed box and one in the chamber. In the second case the lock will be home and the carrier will be clear of cartridges.

How Taught:

- (a) Prepare gun, i. e., load.
- (b) Press thumb piece.
- (c) Explain.
 - (1) Safety catch raised.
 - (2) Thumb piece pressed.
 - (3) Condition of lock when pressure is released.
 - (4) Condition of lock when ammunition runs out.
- (d) Squad practices.
- (e) Ask questions.

3. How to Unload:

Pull roller handle to the rear (without pulling the belt) twice and let the roller handle fly forward onto the deadstop each time. Release top and bottom pawls and pull belt from feed box. Then press the thumb piece.

How Taught:

- (a) Prepare gun, i. e., load.
- (b) Demonstrate unloading.
- (c) Explain.
 - (1) Roller handle twice on roller.
First time roller handle comes to rear it grips two live rounds, one drops out, other is placed in chamber.
Second time roller handle comes to rear it does not grip cartridge because you do not pull the belt.
 - (2) Pawls released from belt.
 - (3) Thumb piece pressed.
 - (4) Belt removed and replaced.
- (d) Squad practices.
- (e) Ask questions.

4. Action on Recoil:

Suppose the gun to have just fired the cartridge. Carrier will be gripping a live round in the feed box and an empty case in the chamber. The explosion will cause the recoiling parts to move backward through a distance of about one inch, thereby extending the recoil spring. This back movement is due partly to the effect of recoil and partly to the effect of the muzzle attachment which acts as follows: The powder gasses which escape through the muzzle after the exit of the bullet, strike violently against the front disc and rebounding against barrel disc, drive it and the barrel to which it is attached, backward. The gases then escape through the openings in the sleeve.

How Taught:

- (a) Prepare gun.
 - (1) Remove sleeve.
 - (2) Empty case in chamber.
 - (3) Live round in feed box.
 - (4) Remove recoil spring.
 - (5) Raise rear cover.
- (b) Demonstrate by pushing back recoiling parts from front.
- (c) Explain.
 - (1) Force of explosion.

- (2) Action of gas in muzzle attachment.
- (3) Recoiling parts driven back.
- (4) Recoil spring extended.
- (d) Squad practices.
- (e) Ask questions.

5. First Action in Feed Box.

As recoiling portions go to rear the recess in the extension of left recoil plate carries with it the stud on the bottom lever of the feed box. The bottom lever, acting on the upper lever causes the slide to move to the right, enabling the upper pawls to engage the next cartridge already held in position by the bottom pawls.

How Taught:

- (a) Prepare the gun.
 - (1) Remove the muzzle attachment.
 - (2) Empty case in chamber.
 - (3) Live round in feed box.
 - (4) Remove recoil spring.
 - (5) Raise front cover.
- (b) Demonstrate by pushing back recoiling parts from the front.
- (c) Explain.
 - (1) Stud on bottom lever.
 - (2) Recess in extension of left recoil plate.
 - (3) Bottom lever acting on upper lever.
 - (4) Slide moving to right.
 - (5) Upper pawls engaging cartridge held by bottom pawls.
- (d) Squad practices.

6. Backward Rotation of Crank:

The backward movement of recoil causes the tail of the roller handle to roll on the roller, thereby rotating the crank. The rotation of the crank withdraws the lock and causes the fusee to wind the fusee links, thereby further extending the recoil spring. Owing to the momentum of the lock, connecting rod, crank and roller handle, the roller handle continues to roll on the roller. The continued rolling combined with the action of the recoil spring forces the barrel and recoil plates forward, but the lock travels back about one more inch before joining in the general forward movement. The barrel and recoil plates are now home.

How Taught:

- (a) Prepare gun. Same as in No. 5, except raise rear cover
- (b) Demonstrate by pushing on barrel disk till roller handle is vertical then push back on carrier.
- (c) Explain.
 - (1) Tail of roller handle on roller.
 - (2) Crank rotates, lock withdrawn.
 - (3) Recoil spring further extended.
 - (4) Momentum of lock causes further rotation of crank.
 - (5) Barrel and recoil plates travel forward.
 - (6) Lock goes back one inch, then goes slightly forward.
 - (7) Barrel and recoil plates fully home.
- (d) Squad practices.
- (e) Ask questions.

7. Second Action in Feed Box.

As the recoiling parts go forward, the recess in the extensions

of the left recoil plate carries with it the stud on the bottom lever of the feed box. The bottom lever, acting on the top lever, causes the slide to move to the left, the top pawls bringing a cartridge into exact position against the cartridge and bullet stops (by means of the cartridge guide), ready to be gripped by the carrier. As the belt passes through the feed box, it depresses the bottom pawls which rise again behind the second cartridge in the feed box and so prevents the belt from slipping out when the carrier removes the first round.

- (a) Prepare gun.
 - (1) Remove muzzle attachment.
 - (2) Half load.
 - (3) Remove recoil spring.
 - (4) Draw recoiling parts back.
 - (5) Raise front cover.
- (b) Demonstrate.
 - (1) Force recoiling parts forward.
 - (2) Slide moves to left.
- (c) Explain (with feed box and two dummy cartridges or diagram).
 - (1) Recess in left recoil plate.
 - (2) Stud on bottom lever.
 - (3) Bottom lever acting on top lever.
 - (4) Slide moves to left.
 - (5) Upper pawls. Fresh cartridge.
 - (6) Cartridge guide and cartridge and bullet stops.
 - (7) Bottom pawls depressed.
 - (8) They rise behind second cartridge.
- (d) Squad practices.
- (e) Ask questions.

8. Outside and Backward Action of the Lock.

As the lock moves backward the carrier withdraws a live round from the feed box and an empty case from the chamber. The horns of the carrier move along the top surface of the cams until the cartridge is clear of the belt. When the carrier arrives at the end of the cam, it is forced down by the cover guides thus bringing the cartridge drawn from the feed box in line with the chamber, meanwhile the empty case may have dropped off the face of the carrier. The live round is prevented from falling off the face of the carrier by the bottom projection of the gib.

How Taught:

- (a) Prepare gun.
 - (1) Remove muzzle attachment.
 - (2) Empty case in chamber.
 - (3) Live round in feed box.
 - (4) Remove recoil spring.
 - (5) Raise rear cover.
- (b) Demonstrate the action of the lock moving backward.
- (c) Explain. (Use diagrams.)
 - (1) Withdrawal of live round from feed box.
 - (2) Withdrawal of empty case from chamber.
 - (3) Horns traveling on cams.
 - (4) Rear cover guides forcing down carrier.
 - (5) Empty case may have dropped off.
 - (6) Live round opposite chamber.
 - (7) How live round is held on carrier.
- (d) Squad practices.
- (e) Ask questions.

9. Inside or Cocking Action of Lock.

The rotation of the crank gives an upward movement to the side lever head and cross head. The side lever head bears upon the tail of the tumbler, rotating it on its axis, causing the firing pin to be withdrawn. The long arm of the main spring acts on the projection of the firing pin, while the short arm bears against the nose of the hand sear, consequently the withdrawal of the firing pin compresses the main spring. As the tumbler rotates the nose of the of the main spring but they do not engage, for the continued hand sear is forced over the bent of the tumbler by the short arm rotation of the tumbler withdraws the firing pin still further until the bent of the safety sear engages with the bent of the firing pin through the action of the sear spring.

How Taught:

- (a) Prepare gun.
 - (1) Empty case in chamber.
 - (2) Live round in feed box.
 - (3) Thumb piece pressed.
 - (4) Rear cover raised.
- (b) Demonstrate.
 - (1) With gun by drawing the roller handle to the rear.
 - (2) With brass lock.
- (c) Explain (with brass lock, diagrams or spare parts).
 - (1) Upward movement of side lever heads.
 - (2) Rotation of tumbler.
 - (3) Withdrawal of firing pin
 - (4) Compression of main spring.
 - (5) Nose of hand sear over bent of tumbler.
 - (6) Bents of safety sear and firing gun.
- (d) Squad practices.
- (e) Ask questions.

10. Action of Recoil Spring.

When the force of the explosion is exhausted the recoil spring takes command and unwinds the fusee links from the fusee, giving a rotary movement to the crank. This imparts a forward and downward movement to the side lever head and cross head, thereby causing the lock to continue its forward movement.

How Taught:

- (a) Prepare gun.
 - (1) Half load.
 - (2) Remove recoil spring.
 - (3) Raise rear cover.
 - (4) Draw back roller handle and pull belt.
- (b) Demonstrate.
 - (1) Attack recoil spring to links. Hold roller handle back.
 - (2) Pull on spring and let go roller handle.
- (c) Explain.
 - (1) Connection of recoil spring and links to the crank.
 - (2) Downward movement of connection rod and side leverhead.
 - (3) Lock forced to continue forward movement.
- (d) Squad practices.
- (e) Ask questions.

11. Forward Movement of the Lock.

As the lock travels forward the carrier places the live cartridge in the chamber, and the carrier is caused to rise by the side levers acting on the lifting levers. As the carrier rises, the empty case, if it has not already fallen off, will be forced off by the seating for ejection. The bottom projection of the gib slides over the base of the cartridge held in the chamber, and the firing pin hole is brought up opposite the cap, while a fresh cartridge is gripped automatically in the feed box. When the carrier reaches its highest point, the holding up springs engage in the grooves cut in its side, to prevent the horns of the carrier falling and fouling the front end of the cams, at the commencement of its backward movement, if the bents of side and lifting levers are worn. This can only happen when no cartridges are on the face of the carrier. A further downward movement of the side lever head below the horizontal, allowed for by the bents of the side and lifting levers, enables the sear to be depressed and the breech locked.

How Taught:

Set up gun.

- (1) Half load.
- (2) Remove recoil spring.
- (3) Roller handle on to roller.
- (4) Pull belt.
- (5) Raise rear cover.
- (a) Demonstrate. Action outside of lock in forward movement.
- (b) Explanation. (Use spare lock.)
 - (1) Live round opposite chamber.
 - (2) Side levers acting on lifting levers.
 - (3) Carrier rises.
 - (4) Show empty case (if still on carrier) forced off by seating for ejection.
 - (5) Bottom projection of gib passing over base of live round in the chamber.
 - (6) Firing pin hole opposite cap.
 - (7) Cartridge gripped in feed box.
 - (8) Holding up springs.
 - (9) Further downward movement of connecting rod and side lever head.
 - (10) Breech block.
- (c) Squad practices.
- (d) Ask questions.

12. Firing Action. (Firing of First Shot.)

When the sear was depressed its bent was released from the bent of the firing pin. This enables the firing pin to be carried slightly forward by the main spring, until bent on tumbler engages the nose of the hand sear. If the safety catch is raised and the thumb piece pressed the pawl near the bottom of the trigger bar lever, this being pivoted in the center, causes the top to come to the rear, engaging a projection on the trigger bar and drawing it backwards. As the trigger bar is drawn backwards, the front end of the slot engages and draws back with it the tail of the hand sear, thereby releasing the nose of the hand sear from the bent of the tumbler. The long arm of the main spring takes the firing pin forward on to the cap and explodes the cartridge.

How Taught:

Set up gun; load.

(a) Demonstrate:

- (1) Use brass lock, spare parts, or diagram.
- (2) On gun firing first shot.

(b) Explain: (With brass lock.)

- (1) Bents of safety sear and firing pin.
- (2) Main spring taking forward firing pin.
- (3) Nose of hand sear on bent of tumbler.

On gun.

- (1) Pressing of thumb piece.
- (2) Pawl on trigger lever.
- (3) Action of trigger lever.
- (4) Trigger bar drawn to the rear.
- (5) Tail of hand sear drawn back.

With brass lock.

- (1) Nose of hand sear disengaged from bent of tumbler.
- (2) Action of long arm of main spring.
- (3) Firing pin explodes charge.

(c) Squad practices.

(d) Ask questions.

13. Subsequent Shots.

The firer, by maintaining pressure on thumb piece, holds back the trigger bar. Therefore, each time the lock goes forward the front end of the slot holds back the hand sear before the lock is quite home. By this means the nose of the hand sear is prevented from engaging in the bent of the tumbler. When the lock is home, the side lever head depresses the safety sear, thus permitting the long arm of the main spring to carry the firing pin on to the cap, and the charge is exploded. The depression of the safety sear is so timed that the firing pin cannot be released until the lock is in the firing position.

How Taught:

Set up gun; load.

- (a) Demonstrate firing of subsequent shots with brass lock, spare parts or diagrams.
 - (1) Pressure kept on thumb piece.
 - (2) Trigger bar kept back.
 - (3) Tail of hand sear held back before lock is home.
 - (4) Nose of hand sear and tumbler.
 - (5) Depression of safety sear.
 - (6) Action of main spring.
 - (7) Timing of safety.
- (b) Squad practices.
- (c) Ask questions.

14. Action Upon Releasing Pressure on Thumb Piece.

On releasing pressure on thumb piece the trigger bar is allowed to resume its normal position. The short arm of the main spring forces the nose of the hand sear under the bent of the tumbler, so that when the safety sear is depressed the nose of the hand sear engages in the bent of tumbler, and the firing pin is unable to go forward.

How Taught:

Set up gun; load.

(a) Demonstrate:

- (1) With gun; trigger bar action on release of pressure.
- (2) Brass lock or spare parts, action of hand sear.

- (b) Explain:
 - (1) Safety catch spring and trigger bar lever.
 - (2) Trigger bar spring and trigger bar.
 - (3) Safety sear depressed.
 - (4) Firing pin held by hand sear and tumbler.
- (c) Squad practices.
- (d) Ask questions.

SIGHT-SETTING AND LAYING.

(Ref. M. G. Firing Manual.)

Importance.

Kit required for teaching: Gun, tripod, 2 belt boxes, aiming disc bulls eye target of 1" at 10 yards, landscape and figure targets.

1. Use of sights; to give elevation and direction.
2. How to adjust sight leaf and aperture disc.
3. Rules for aiming.
 - (a) Sight upright.
 - (b) Close one eye.
 - (c) Alignment of sights on target.
 - (d) Aperture sights and open sights.
4. Use diagrams to show proper method of aiming.
5. Instructor lays an aim without holding and explains the correct use of the elevating wheel and traversing clamp.
6. Class inspects instructor's aim.
7. Class lays an aim as taught.
8. Common errors in laying:
 - (a) Leaning sights.
 - (b) Eye focused on sights instead of target.
 - (c) Varying amount of front sight.
 - (d) Inaccurate centering of the front sight.
9. To show error in laying, use paper and hide target while recruit properly aligns the sights.
10. Triangle of sight error.
11. Laying with holding.

TRAVERSING, SEARCHING AND OBLIQUE TRAVERSE.

Equipment required to teach: Gun tripod, belt and box, dummies, instructional figure target.

Method of Teaching Traversing.

1. Gun mounted 1000" from target and the object of the lesson explained. Figure 4" apart and a 2 mil tap—2" at 1000".

OBJECT: To develop an automatic tap of two mils and to learn the stickiness required in the traversing clamp.

The instructor with a No. 2 will demonstrate and explain:

- (a) Strong tap and tight clamp is best.
- (b) When tapping with either hand the gun must be held properly with the other, safety catch raised.
- (c) Eyes on the target.
- (d) No. 2 adjusts clamp on orders from No. 1.
- (e) When testing for tightness, look along sights.

Thumb piece pressed between taps.

SEARCHING: Object explained and demonstrated as before.

1. Turn wheel firmly.
2. Eyes on target except when learning.

OBLIQUE TRAVERSING: Object explained and demonstrated.

1. Proper sequence followed:
Fire—Tap—Elevate.
 2. Tapping must be automatic.
 3. Sights used when elevating or depressing.
- SWINGING TRAVERSE:** Explain when used.
1. A little stickiness is best.
 2. Move gun with whole body.
 3. Thumb piece pressed when gun starts to move.

IMMEDIATE ACTION.

Extremely important. Don't try to teach causes, just I. A. Visual instruction best.

Kit required: * Gun, tripod, ammunition box, belt, dummies, prepared dummies, target, cloth, tool box complete.

General Remarks:

The various I. A.'s are based on the position of the roller handle.

First position. In back of the vertical.

Second position. In front of the vertical.

Third position. Just above dead stop.

Fourth position. On dead stop.

NOTE—I. A. is not complete until the gun is re-layed and the thumb piece pressed.

Don'ts for VICKER'S GUN:

1. Don't pull on the chains.
2. Always use the correct tools.
3. Always see that screws are fully home and tight.
4. Never throw covers back.
5. Put the feed box in correctly.
6. When closing the front cover always have the catch up.
7. Never use direct hammer blows on any part of gun.
8. Lock must always be in correctly.
9. Always pull back R. H. before opening rear cover.
10. Life of M. G. depends on how handled.

SEQUENCE OF INSTRUCTION.

1st Position.

Kit required (see above).

Pull R. H. back onto roller belt to left front, relay and commence firing. Should stoppage recur, lighten recoil spring three clicks (towards gun) first repeating I. A. as above. No. 1 may also call "Barrel disc." **Note:** In range firing always use triangle sight, holding eye six inches from tangent sight.

2nd Position.

1st Part. Note the position of the R. H. Call clearing plug. Knock down sights with left hand, pull R. H. back on to roller, raise rear cover and remove lock, ease R. H. down on to dead stop, examine shell, if bulged remove, replace lock, lower cover, fully load, sight up, relay, and resume firing.

2nd Part. Same as in first part, only if shell is not bulged, insert clearing plug, put in lock, let R. H. fly forward and withdraw, remove plug and ruptured case, reload, relay and fire, as above.

3rd Position.

1st Part. Ease up slightly on R. H. belt to left front, strike R. H. a glancing blow, relay and carry on firing.

2nd Part. Proceed as in part one—no results—feel top pawls—if fixed—call "feed box."

Pull R. H. onto roller, raise front cover to an angle of 45 degrees, two fingers in feed box, two under cover, thumb over cover, and with the assistance of No. 2 raise feed box and call "straighten belt." As soon as No. 2 has released belt he pushes slide to left calling "right," No. 1 then fixes front cover, No. 2 straightens rounds in belt, and again calls "right." No. 1 pulls belt to left front, releases R. H., relays and commences firing.

3rd Part. Slightly raise R. H., pull belt, strike R. H. glancing blow. If this does not remedy stoppage feel the slide, if slide is free call "carrier," open front cover so that No. 2 can force carrier down, close front cover, tell No. 2 to take out first round in belt, open rear cover and call "New lock," replace new lock, close cover, reload, relay and fire.—P. T. O.

If you get a recurring No. 3, in part one, call for oil and oil face of carrier.

4th Position.

1st Part. Position of R. H. on dead stop.—Pull roller handle to rear, pull belt, release R. H. relay, fire.

2nd Part. If on pressing thumb piece gun does not fire, unload and change lock, reload, relay and fire.

3rd Part. Pull roller handle back on roller and if on pulling belt it comes through the feed box too far, fully load, relay and fire

COMPETITION TEST IN I. A.—PENALTIES.

Each man starts with 20 per gun, —4 guns, —80.

Totally wrong, I. A., —20.

Starts wrong, then right, —5.

Gun not reloaded, —5.

Clumsy or too much reloading, —2.

Not relaying, —10.

Relaying wrong target, —5.

Incorrect aiming, —1 —5.

Not pressing thumb piece, —2.

Lock forward, cover up, —5.

Rear cover not latched, —5.

First position omitting to pull belt, —5.

Recurring if spring not altered, —3; wrong way, —10.

Using clearing plug—not required, —5.

If do not say not required, —5.

Cover improperly held, —5.

Clumsy, —2.

Attempt to clear and fail, —5.

Try to clear again, —20.

Failing in 1st I. A., —10.

Failing to feel slide, —5.

R. H. not on roller, —5.

If slide is free to change locks, —5.

Not calling carrier, —5.

4th Position.

If change lock on 1st miss fire, —10.

If 2 successive miss fires do not change lock, —10.

If don't unload before changing locks, —5.

Credit and debit 1—class average—time.

POINTS BEFORE FIRING.

1. Oil working parts.
2. Dry bore, front disc and barrel disc. Barrel disc secure.

3. Test recoil parts.

- (a) Remove recoil spring and box, place handle vertical, work back and forth, then weigh with spring balance. Read scale on first movement of recoil parts to rear. Should be from 2 to 4 pounds.

4. Weigh recoil spring.

- (a) Take out lock. Read at first movement of handle. Read three times and take mean. Proper weight 7 to 9 pounds.

5. Look to water in casing and in reserve.

6. Examine spare parts.

7. Examine oil in handle block.

8. Examine belts and ammunition:

9. Examine tripod.

10. Be especially careful in cold weather.

POINTS DURING FIRING.

1. Watch water supply.

- (a) Begins to boil after 600 rounds. Consumption of water depends on weather, rate of fire; average 1½ pints to 1000 rounds.

2. Watch belts.

- (a) Alignment.

DURING A TEMPORARY CESSATION.

1. Oil working parts.

2. Examine muzzle attachment and barrel disc.

3. Replace partly emptied belt.

4. Refill empty belts at once.

5. Examine tripod.

6. Wise to weigh recoil spring after heavy firing.

7. All repairs quickly attended to.

8. Examine jamming handles and joint pins.

POINTS AFTER FIRING.

On the Range.

1. Unload.

2. Take belt from feed box.

3. Release main spring.

4. Oil bore, muzzle attachment, and barrel disc.

5. Empty water jacket.

6. Sort live rounds from empties.

7. On arrival at barracks, strip and clean thoroughly, leaving gun slightly oily.

8. Pack guns in cases after cleaning.

9. Enter number of rounds fired and breakages, if any, on history sheet.

10. Check spare parts.

11. Clean and repair belts.

12. Make out breakage report.

In the Field.

1. Unload and clean belts.

2. Release mainspring.

3. Clean bore.

4. Fill water jacket.

5. Oil up.

6. Fill handles.

7. Weigh recoil springs.

8. New belt (replace).
9. Half load and press thumb piece.
10. Look to ammunition supply.

T. O. E. T.

Drill as Per M. G. Drill Regulations (Prov.) 1917.

	Time
Mount gun	20 seconds
Load	5 seconds
Sight setting and laying	8 seconds
Unload	5 seconds
Dismount	15 seconds
Loading belt (hand)	12 mins. 25 rds. per min.
Loading belt (machine)	3 mins.
Action	35 seconds

SETTING UP STOPPAGES.

1. Kit required same as I. A.
2. Also give general remarks same as I. A.
3. Squad seated on right of gun instructor.
4. Have One and Two to perform I. A. They do not turn head away.

Note.—“When stoppage is set up, knock off aim, giving order,” “Holding” and remove cloth. After student has performed I. A., give command “Cease Fire,” and check aim.

5. Class must know reason for stoppage before setting up.

1st Position.

1. Weak explosion.
2. Too heavy recoil spring.
3. Want of oil or frozen oil.
4. Grit in recoiling portions.
5. Tight pockets “Or wet belt.”
6. Excessive packing.
7. Worn barrel.
8. Friction.

Note.—All the above except No. 1 will give a recurring stoppage.

2nd Position.

1. Damaged round.
2. Separated case.

3rd Position.

- | | |
|----------------------------------------------------------------|-----------------|
| 1. Cross fed cartridge. | } Slight fault. |
| 2. Friction in lock | |
| 3. Bent long brass strips. | } in feed. |
| 4. Badly filled belt. | |
| 5. Torn or worn pockets. | |
| 6. Loose pockets. | |
| 7. A belt box not in line. (No. 3 to No. 7 bad fault in feed.) | |
| 8. Damaged cartridge grooves. | |
| 9. Broken gib, or spring. | |
| 10. Thick rimmed cartridge. (8 to 11 carrier stoppages.) | |

4th Position.

1. Empty pocket.
2. Miss-fire.
4. Broken main-spring.

Stoppages Not Immediate Action.

Broken recoil spring, fusee or links, remedy R. H. on dead stop, remove recoil spring box, spare parts.

PROLONGED STOPPAGES.

(i) Due to gun or some part which, as a rule, cannot be put right by gun team, under fire, or without the aid of a mechanic.

(ii) Runaway gun, caused by nose of hand sear or bent of tumbler becoming worn or broken.

To Set Up—Give command “load” and on R. H. reaching dead stop the second time, call out “gun is firing.”

Remedy—Throw belt over feed box—which may cause bad fault in feed (No. 3 stopping), and if so, No. 1 pulls R. H. onto roller and throws belt back into position, raises front cover and carries out I. A. for bad fault in feed, with the exception that No. 2 does not replace belt and No. 1 allows R. H. to go forward, firing round held by gib. Change locks, unload, relay, etc.

If new lock not at hand, No. 1 will have No. 2 space rounds in belt according to the bursts he wants to fire. He then half loads R. H. onto roller and while holding it there relays onto target, having first pulled belt to left front—raises safety catch and when ready to fire, releases R. H. and at once takes proper holding. Gun will now fire until number of rounds are used up, when the above will be repeated.

A No. 4 stoppage may occur, in which case, apply I. A. and proceed as above.

Broken Recoil Spring. Gun will stop with R. H. on roller, To set up—half load, remove recoil spring and box, and replace box with spring not connected, next bring R. H. onto roller and pull belt to left front.

I. A., return R. H. to dead, stop, if possible, remove recoil spring and box, and replace new spring, taking care to put the same tension on it as the old spring had. Note position of tension screw before removing broken spring. Replace box, spring, reload, relay, fire. If fusee broken, change fusee, etc.

If it is to be a No. 3 stoppage, half load and hang lock, pull recoil portion to rear and place round between barrel disc and front disc. Then bring R. H. to roller and release.

I. A., first same as No. 3 stoppage, No. 2 force down carrier, No. 1 clean face of carrier and tells No. 2 to remove belt, he then places in lock, and hangs the same, pulls recoil portions to rear and tells No. 2 to remove broken disc and replace new one, then reloads, etc.

If no barrel disc is available, reduce tension to, from two to three pounds, so as to neutralize force of explosion with tension. This will reduce rate of fire.

Broken barrel disc will cause recurring No. 1, and No. 1 has No. 2 examine barrel disc, and if broken, No. 1 applies I. A., for No. 1 stoppage, unloads and has No. 2 put on a new disc. If none available take off tension on recoil spring to extent of two to three pounds, reloads, relays, etc.

REPAIRS AND ADJUSTMENTS.

1. Kit required.
2. General remarks.
3. To fit a new disc on the front disc of the muzzle attachment.
4. To temporarily repair a perforated water jacket.
5. To weigh and adjust the recoil spring.
6. To weigh the recoiling portions.
7. To test and adjust the length of the connecting rod.
8. To pack the barrel.

9. To repair a torn belt.
10. To use belt repairing tool.
11. To repair lock.
12. To adjust the tripod.

1. Kit Required.

Gun, tripod, spare parts complete, spare barrel, part of an old barrel.

2. General Remarks.

All must be able to do the repairs and adjustments mentioned in this list. The maintenance of fire power depends upon the ability of the gun crew to do those things.

(b) Subject should be taught in the above sequence.

3. Remove front cone with the spanner, cut a small slit in the front disc and remove it with pliers. Put a new disc on, and press it down with the thumbs. Place piece of wood and tap until home.

4. Make a mud cake and bind it over hole or use plastersine.

7. Unload and release main spring, remove recoil spring and box. Take one 3/1000 and one 5/1000 washer from spares, feel them to tell the difference. Take out lock and place the washers on the shoulder of the connecting rod. Replace lock and insert gage from the bottom and place it over the firing pin hole. Raise the carrier to the fullest height and turn roller handle toward the dead stop. Two things might happen. You may or may not feel a check. If you feel a slight check the connecting rod is the correct length. If you do not, pull roller handle to the rear and remove the lock, and the washers from the connecting rod shoulder. Remove the adjusting nut and place on the two washers. Replace the adjusting nut and place two more washers on the connecting rod shoulder. Repeat test.

11. Lock Repairs.

- (a) To change tumbler, drive outside lever pins and remove side lever and lifting levers. Remove tumbler pin and tumbler. Replace tumblers, reassemble and test.

To change carrier: cock the lock.

Remove side lever pins.

Remove side lever.

Remove lifting lever.

Remove carrier.

Re-assemble.

- (c) To change the firing pin.

Strip to safety sear in same sequence as instructed in stripping.

- (d) To change safety sear.

Same sequence.

- (e) To change hand sear.

Cock the lock.

Remove side lever pins.

Remove side lever.

Remove lifting lever.

Keep carrier fully up.

Depress safety sear and fire the hand sear.

Remove hand sear pin, hand sear and main spring.

To assemble: Rotate the tumble until the firing pin is engaged with the safety sear. Replace hand sear

and pin, lifting and side levers and pins. Place the lock on a firm base, depress the safety sear and hand sear and replace the main spring.

- (f) NOTE: If main spring is broken, try to shake it out.

TARGET DESIGNATION.

CLEAR, CONCISE AND COMPLETE.

Designation that will fully point out the target in the fewest words possible will be, "Clear, Concise and Complete."

When reference is not made to Plate 1 the conditions are purely imaginary.

1.

When the object is perfectly obvious it should be named without reference to clock rays or reference point: This may occur when there is but one object of its kind in your particular sector.

Example:

A. Windmill.

B. Poplar tree.

2.

The type of the target may be such that it is not necessary to make use of either the clock rays or reference point.

Example:

A. Red mill.

B. Broken bridge.

C. Two story house.

D. Lone tree.

3.

Position may fully describe the object.

Example:

A. Right-hand house.

B. Left end of pond.

C. Second bend in road.

D. Between church and bridge.

4.

Horizontal clock rays.

NOTE: Care must be taken that the "setting rays," of all interested in the problem, coincide.

This method is usually employed for giving the general direction only.

Sequence:

1. Ray.

2. Name.

Example:

A. Ten o'clock—house.

B. Ten o'clock—second house.

C. One o'clock—bridge.

D. Two o'clock—vineyard.

5.

Reference point method.

Any of the above methods may be used to describe the position of the reference point which should be the closest distinct object you wish to draw attention.

Theoretically the error, in describing an object 100 mls from the reference point will be ten times as great as if it was but ten mls away.

Observation conditions will rarely be the most favorable either from the position of the observer or the condition of the field of view, making designation and recognition difficult.

The following sequence is the most logical when pointing out a target with reference to some other point.

Sequence:

1. Direction.
2. Distance.
3. Name.

Example:

Reference point A—

1. Four thirty o'clock.
2. Ten mls.
3. "B" (See Fig. 1.)

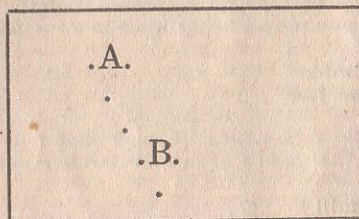


Fig. 1

Had you used the following sequence:

Sequence:

1. Distance.
2. Direction.
3. Name.

You probably would have caused the observer to look in any direction from the point A, as is illustrated by the circle in Figure 2, at the instant you had given "Distance."

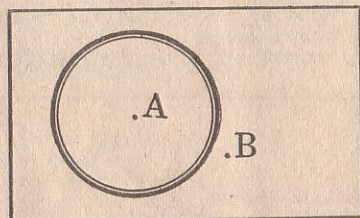


Fig. 2

Sequence: (Including reference point.)

1. Reference point.
2. Direction.
3. Distance.
4. Name.

Example:

- A.
 1. Reference point door in mill.
 2. Three thirty o'clock.
 3. Eleven mls.
 4. I saw what I thought to be someone move.
(See Plate 1.)
- B.
 1. Ten o'clock: Reference point—chimney on house.
 2. One o'clock.
 3. Seven Mils.
 4. I saw muzzle blast.
(See Plate 1.)
- C.
 1. Row of small trees along fence. Reference point left hand tree.
 2. Eleven thirty o'clock.
 3. Eight mls.
 4. Soldiers approaching down the connecting trench, in pairs, at intervals of about one minute.
(See Plate 1.)

The fire order for designation of "C," designation should be:

1. 2000.
2. Row of small trees along fence.
3. Base of left hand tree.
4. Three mls left.
5. Rapid.
6. Fire.

NOTE: It is assumed that the platoon leader, in giving this order, knows the range to the point "C" to be 1,400 yards and, by the use of the graticule or inverted sight, found the reading, on the tree to be 2,000.

6.

When the target has width or depth.

Example:

- | | |
|------------------|--------------------------------------|
| Reference Point. | 1. Row of small trees along fence. |
| | Reference point—2nd tree from right. |
| Direction. | 2. Twelve o'clock. |
| Distance. | 3. Seven mls. |
| Direction. | 4. Extending toward three o'clock. |
| Distance. | 5. Ten mls. |
| Name. | 6. Front line trench. |
| | 7. |

Special condition:

Using rectangular co-ordinates.

The first reference point is given and from it the direction of the horizontal ray is determined by the position of the second reference point but the direction of the vertical ray, from the second reference point must be given in vertical clock direction.

Example:

- A.
 1. Mill—row of trees along fence—left hand tree.
 2. Six o'clock.
 3. Small bush seems to have been disturbed.
(See Plate 1.)
- B.
 1. Bridge—dead horse.
 2. Twelve o'clock.
 3. New work.

NOTE: When the target is indistinct and there is plenty of time the fire control officer may lay the gun.

BREAKAGE REPORT.			
Date	Article	To When Reported	Remarks

METHOD OF INSTRUCTION.

1st Lesson.

Correct names of parts.

2nd Lesson.

Proper method of packing.

3rd Lesson.

Competition in packing.

Blindfolded work is excellent.

Belt Filling by Hand.

Best known time 4' 50".

Standard time 12' (25 rounds per minute).

Very important that a high standard be reached.

Open pockets with left hand: Insert rounds with right.

Knee Method.

Sit cross legged, ammunition box on right, water-proof sheet on left, belt running across knees, rounds between legs.

Finger Method.

Belt held in front and fed toward body. Best Method. Observation of condition of belt and ammunition is absolutely essential during any feeding.

Blindfolded filling is essential. Should have an hour daily on hand filling.

ROUGH GROUND DRILL.

Kit Required:

Gun, tripod, two belt boxes, dummies, condenser tube and water box.

Preparation:

Select a suitable piece of ground with a good steep slope and with one or more service targets, visible from top of slope (bridges, gaps in roads, etc.).

How Taught: (Two Stages.)

1. Instructor demonstrates how tripod is mounted for different slopes and the positions of No. 1 for each. Instructor demonstrates how to dismount—explains both.

Squad Practices: Points to Note.

2. Actually mounting gun, duties of No. 2, and 3-4. Rear leg always down hill, socket upright, shoes only engaging in ground, always clear socket at least one hand's width from ground. Essential object, clear field of fire, full traverse if possible no higher mount than necessary, use of background. When gun is mounted it is turned toward the target. Between No. 3-4 is an ammunition dump.

Out of Action.

"a" Cover near 1-2, pick up gun and amm. and carry back.

"b" Cover close 1-2, pull gun down.

"c" No cover near, dismount and retire on signal from No. 1.

USE OF GROUND AND COVER.

It is essential that troops shall be trained early and thoroughly in the use of ground and cover. Point out the many minute features of ground that will hide a man. The general principle is that

ground and cover must be used to produce the maximum fire power with the minimum exposure.

Study the ground from a topographical view point, from intelligence view point, crops, streams, inhabitants, railroads. From a tactical view point, the selection of tactical and military features. The habit of a tactical study should be cultivated.

Reconnaissance proper should be done in various ways:

1. Personal.
2. Field glasses or telescope.
3. Maps—prepared in peace times and brought up to date.
4. Aerial photography.
5. Intelligence services.
6. Train N. C. O.'s in map making and reading.

Cover.

- (a) Cover from fire—rifle or shrapnel. Protection from other fire is impossible. Dangers from close cover dugouts, pill boxes, etc.
 - (i) Reduction of moral.
 - (ii) Fumes and gases.
 - (iii) Limited field of fire or loophole; must get fire effect even if it means leaving cover.
- (b) Cover from view. May be either natural or artificial. Natural cover is best, due to the possibility of well trained eyes detecting artificial cover. Natural cover aids surprise—offers better field of fire. There should be a covered line of communication and alternative gun positions. Should always have shelter close in rear for men not actually with guns.
- (c) Cover afforded by your own fire. May be in the open and entirely safe if you have fire superiority.
- (d) Cover from aerial observation. This is now absolutely necessary and becoming more so. Planes fly very low (200 feet) to discover gun positions.

Camouflage is absolutely necessary, not only in the gun position, but also the line of supply. Foot prints show very plainly in aerophotos. Men must not move in the gun positions.

In selecting gun positions bear in mind the enemy view point.

AVOID a natural aiming mark, conspicuous and isolated cover, whenever possible, ground that the enemy can easily observe.

Principles affecting the selection of gun positions:

1. A position is a line, not a point—lines of supply and communication must be established.
2. Provide alternative positions. Squads know position and approaches.
3. Good lines of advance and withdrawal.
4. Have protected flanks.
5. Select positions with a view to the proposed action—obtain best cover possible and insure fire effect and control.

NEVER sacrifice fire effect to concealment or protection, or occupy a position without considering the foreground and background.

In selecting positions observe the following method:

1. Place yourself in the exact firing position.
 2. Take range finder with you in order to **know** distance.
 3. Select control post.
Should see your guns.
 4. After selection consider the position from the enemy view point.
- Use both cunning and common sense.

EXAMPLES OF POSITIONS.

1. Natural.

- (a) Bulge or small undulation in the ground—18" deep.
- (b) Mound of earth may give cover from fire.
- (c) Banks, ditches, hedges, etc. See that they are not enfiladed.
- (d) Middle of field of growing crops—turnips, potatoes, carrots, etc.
- (e) Woods and trees.

2. Artificial.

- (a) Barracades in the road. Better to use as a background or to fire indirectly over them.
Usually best to avoid these positions and to fire from side of the road.
- (b) Haystacks—on top or behind for flanking fire or in front and covered.
- (c) Houses and buildings, re-inforced cellars.
- (d) Wood piles, corn shocks.
- (e) Shell holes, etc.

How to Conduct a Concealment Demonstration.

In preparation a position will have to be selected to bring out certain points.

1. Background.
2. Foreground.
3. Movement around gun.
4. Necessary to keep "white" covered.
5. Skyline.
6. Effect of shape on visibility.
7. Line of supplies—No. 3.
8. Effect of light—considered from the enemy view point.
9. Smoke—steam—noise.

An artificial camouflage should be given on another day.

To conduct a natural concealment demonstration:

1. Make all preparations two days in advance and have two rehearsals.
2. Select a position for the class and limit their area.
3. Arrange and perfect signals to helpers.

Avoid

1. Positions that are ridiculously hard to find.
2. Positions only applicable to peace conditions.
3. Positions that are difficult to evacuate.

Introduce blank ammunition if possible.

ADVANCED TACTICAL DRILL "A."

The Selection of a Gun Position.

1. Too much training in this work cannot be given.

2. It is of utmost importance that all ranks have an instructive knowledge of the procedure in selecting a position.
3. The first few schemes attempted should be very simple.
4. As errors are reduced speed should be required.
5. Such practice is held to produce team work in the gun crew.

In this drill, if possible, there should be only one small portion of the front indicated from which the target can be seen when the gun is in action. By this means gun teams will be practiced in selecting suitable positions to meet the particular requirements of the situation and thus develop an eye for ground.

In this stage attention will be paid to the following points:

1. There are no tactics involved.
2. Time factor is not kept.
3. See that the ground is used to obtain the greatest concealment in advancing to the gun position from the position of readiness. (This point should be kept in mind by the instructor in selecting his practice positions.)
4. Method of approach to the gun position as regards the carrying of the gun, tripod, ammunition boxes, etc. Concealment will be considered of greater importance than speed within reasonable limits.
5. Insist on proficiency in the lessons taught in rough ground drill and elementary training.
6. The allocation of duties will be carefully noted.

Observers will be sent out to note the invisibility of the team in approach, mounting and action.

PRELIMINARY ARRANGEMENTS.

1. Reconnaissance for ground and target.
2. Target should be of a service nature and difficult for the gunner to see when he comes to reconnoiter the position on which to place his tripod.
3. The position in readiness should be at least 50 yards from the point of action and there should be a position on the flank (100 yards or so) where the remainder of the class can view the target. The target should have a different visual aspect from the two points.

HOW THIS DRILL IS CARRIED OUT.

1. March class to the position of readiness.
2. Detail a gun crew of four men and an assistant instructor who goes with No. 1 to observe his actions. Leave No. 2, No. 3 and No. 4 at position of readiness. Take No. 1 and class to a point where the target may be seen. Point out target to No. 1 and class and define the limits for the gun position. Send No. 1 back to his crew, and after he has told them what he knows and made his preparations, give the signal for action.

METHODS OF CRITICISM.

1. From members of the class.
2. From assistant instructor.
3. Discussion of the whole action.

POINTS TO LOOK FOR DURING THE ACTION.

Did No. 1 give his team the information he had about the target, etc? The actions of No. 1 during reconnaissance. After selecting his position did he signal it to the team?

Erection of the tripod.

Correct range on the sights.

Correct aim on proper target.

Actions and positions of Nos. 2, 3, and 4.

All points of elementary training and rough ground drill.

TACTICAL SECTION DRILL "B."

In this stage an entire section, two guns is exercised on the same progressive lines as teams in the preceding work. All the numbers will be exercised in their particular duties. The general situation must necessarily be somewhat amplified in order to employ scouts and range takers in a realistic manner. An elementary situation should be given and ranges actually taken. The position of the carts will be imagined or represented by a hand-cart, with the Corporal in charge. Casualties may be ordered, but this must not be carried to an extreme.

Supply of ammunition will be actually carried out, empty boxes being passed back. The points to be attended to in TACTICAL SECTION DRILL "A" should be carefully observed.

PRELIMINARY ARRANGEMENTS.

As for Tactical Section Drill "A" except that the position of readiness should be selected with a view to making the advance, reconnoitering, and selection of actual gun positions by the numbers much more difficult. The position of readiness should be at least 300 yards from final gun position.

HOW EXERCISE IS CONDUCTED.

The same procedure as for Tactical Section Drill "A," except that guns will be signalled into action, one section at a time.

CRITICISM.

As for Tactical Section Drill "A."

POINTS FOR CRITICISM.

As for Tactical Section Drill "A," but note should be made whether the positions selected were the best. They should not have been selected just because the target was first seen from them.

RANGING AND RANGE CARDS.

1. Ranging is a means adopted to determine the sight setting to be used to hit a particular target.
2. Range finding, the means or method of determining the distance of the target.
3. Means used to determine range. Judging distance, calculation by eye (halving, bracketing, unit of measure, and appearance of objects).
4. Maps.
5. Range cards.

It is necessary particularly in machine gun work that ranges be determined accurately, since one machine gun can fire as many shots as a great many rifles, and because the gun may be sited by day for night fire it is obvious to secure effective fire, that the fire must be very accurate implying that ranges be known as accurately as possible.

OFFENSE RANGE CARD.

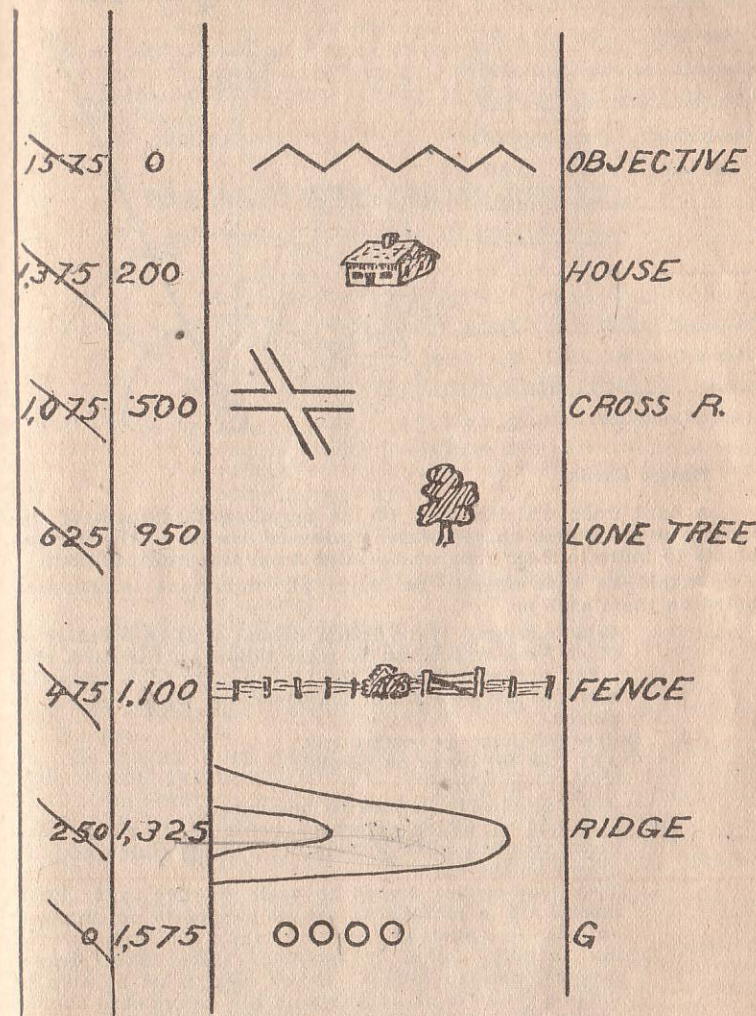


PLATE 2.

MACHINE GUN RANGE CARD

TARGET	R	N	A	S	A	S	C	B
(1) BUSHES	850							60°
(2) MILL	2300							63 30°
(3) ROAD FORK	1920							41 35°
(4) ORCHARD	1250							26 34°
(5) RAVINE	700							-9
	1100							-6 210°

Position 75.60 - 41.35
 Hour & Date MAY 22 '18 6 AM.
 Name JOHN BROWN
 Rank & Organ. 341 MG. Bn.

PLATE 3

Range Cards.

A card upon which ranges of the permanent features of the landscape are noted, and to which lines are drawn to the various points to indicate their general direction from the gun position.

Should be kept simple, but have all important information noted on them such as:

1. **Where Ranges Were Taken From.** Put co-ordinate of place from which ranges were taken on the card, this being necessary due to the tendency to take away the name of the position or emplacement when the gun is moved.
2. **Reference point or setting ray.**
 - (a) As far away as possible.
 - (b) Some object.
 - (c) As clearly defined as possible.
3. The line to which reference point is drawn is very heavy to distinguish it from other lines which may be drawn on the card.
4. Two semi-circles drawn to scale at 600 and 1,000 meters aid in picking up ranges to points not marked on card—see sketch. The targets, as per sketch above using tactical points if possible, have lines drawn proportionate to ranges. Every man must be able to make a range card. Objects on the range card should be varying distances from gun position. The near ranges are not less than 600 yards, for defense range card.

In attack range card particular attention should be paid to near ranges from gun position, as these will become far ranges from the objective in the advance.

Probable Error.

In making any range calculation it is necessary to know what method was used in determining the original range.

1. By eye (trained men), 15 per cent.
2. Range finders, 5 per cent.
3. Maps, 5 per cent.
4. Range cards, 10 per cent.

The trained men, in judging distances by a definite system, use a fixed unit of measure as 100 meters, halved distance, relative size and appearance of objects. (Refer to Provisional Machine Gun Firing Manual.)

5. Determination of range of known objects (mil rule).

TRAINING OF MACHINE GUNNERS.

1. The sequence of instruction in general should be as follows:

- (a) **Preparation—**
Thorough and to include the proper solution of all problems, examples, etc., and the assembling of the necessary material.
- (b) **Demonstration—**
Demonstrate carefully and accurately what you are about to explain.
- (c) **Explanation—**
Clear, in simple language. Be sure that the most backward in the class grasp each point before proceeding to the next.
- (d) **Imitation—**
Class to imitate instructor's demonstration.
- (e) **Interrogation—**
Ask questions to determine whether all understand the subject.

2. **Standard of training required:**
(For allocation of duties see P. M. G. D. R. 1917, W. D. M. G. Tr. Av. 9383-318.)

Officers must lead as well as teach. They must know their subject thoroughly, and present it in such manner as to "get it over" to the men.

All officers must have a thorough knowledge of the technical and tactical principles involved in machine gunnery, and should constantly study human nature, so as to be able to impart their knowledge to others.

Instructors will be most successful who, to the greatest extent, teach by eye, as this is the quickest and surest way of giving instruction.

The officer who does not know his subject will quickly lose the confidence of his men.

Drills and instruction in any form should be varied to promote interest. Make drill periods for each subject short, but while any instruction is being given, insist on undivided attention. Officers must be able to **command** in order to train men properly.

Both officers and N. C. O.'s should have a thorough mechanical, tactical and technical knowledge of the gun. The men must know the mechanical and practical side.

In general—men should be taught only the details of their work, and should not be burdened with the many details which an officer must learn.

Bear in mind that "Bravery without knowledge is suicide."

3. An Enthusiast.

Machine gunners must be specialists and enthusiasts. Teach men that the safety of infantry depends largely upon machine gun success, and in every possible way endeavor to develop discipline, esprit-de-corps and a high standard of morale.

Every man in the squad must know the duties of all others.

Too much stress cannot be laid upon the importance of elementary training, gun drill, I. A., care and cleaning, points B. D. A., firing, rough ground drill, etc.

4. Selection of Personnel. Refer M. G. Tr. Cir. W. D. No. 9383-318.

Men should have six months to one year service in other branches.

In selecting men, consider—

- (a) Intelligence and common sense.
- (b) Education:
Read, write and speak English—N. C. O.'s arithmetic.
- (c) Capable of assuming responsibility.
- (d) Good physique:
Young men—staying power and eyesight, carry heavy loads long distances—running very exhausting.
- (e) Mechanical aptitude or knowledge of animals.

5. Training.

- 1. Psychological—Object to develop high standard of morale—
 - (a) Discipline.
 - (b) Loyalty.
 - (c) Self-respect and pride in organization.
 - (d) Esprit-de-corps—organization spirit.
 - (e) Aggressiveness—initiative.
 - (f) Enthusiasm.
- 2. Physical—To develop muscular strength and agility. In addition to setting up drills, marching, etc., training might include—
 - (a) Shot putting.
 - (b) Weight lifting.
 - (c) Running with and without pack.
 - (d) Jumping.
 - (e) Hurdling.
 - (f) Scaling.
 - (g) Climbing.
 - (h) Digging—pick and shovel.
 - (i) Boxing.
 - (j) Wrestling.
- 3. Mechanical—
 - (a) Mechanism.
 - (b) Stripping.
 - (c) Repairing.
 - (d) Adjusting.
 - (e) Immediate action.
 - (f) Care and cleaning, belt filling, etc.
- 4. Technical and Tactical—Practical drill of all kinds—Important—
 - (a) Infantry drill during recruit stage of training.
 - (b) Gun and section drill, elementary and advanced.
 - (c) Ground and cover drill.
 - (d) Barrage drill.

- (e) Visual training, judging distances, etc.
- (f) Recognition and designation of targets.
- (g) Camouflage.
- (h) Transmission of orders and messages.
- (i) Fire orders.
- (j) Searching, traversing, overhead, night fire—combined sights.
- (k) Use of glasses—periscopes.
- (l) Oral tests.
- (m) Competitions.

6. Tactical:

Making all uses of guns in the occupation of positions and alternatives. Give practice in action under different conditions. Construction of emplacements: Open, splinter proof, shelters, slits, hasty cover. Small problems: Advance, rear and flank guard, attack and defense, covering movements, reconnaissance—with and without glasses.

7. Training With Other Troops.

Machine gunners are not fully trained until they have had practice in the field with infantry, and if possible with artillery, engineers, etc. Study the possibilities and limitations of other arms, and learn to appreciate the problems of both infantry and artillery. (Study F. S. R.)

DUTIES OF INDIVIDUALS.

For Detail see M. G. Training Manual, 1918 (W. P. D. No. 9383-318).

Captain is responsible for all—tactical training, etc.

Second in command must be in very close touch with Company Commander.

The platoon officers are very important. Responsible for platoon training. Must know all situations well. Make reconnaissance of their positions and select gun sites and alternates. Select observation and control post. See to ammunition supply and give order regarding limbers. Select time of approach. Reconnaissance is affected by personal observation, field glasses, maps and aerial photographs.

Section sergeant assists platoon officer.

The non-commissioned officer with limbers must see to water, oil and supplies of all kinds.

No. 1 is always responsible for the gun and tripod assisted by No. 2.

Nos. 3 and 4 attend to ammunition and water supply.

Nos. 5 and 6 and drivers are belt fillers.

CHARACTERISTICS OF MACHINE GUNS.

(Heavy Type.)

1. Development of Fire Power.

The machine gun of today is the result of a constant effort to develop maximum fire power.

An automatic rifle—the French Mitralleuse—was first used at Mais Le Tour, but its characteristics not being understood, the gun

was employed as artillery—with little success. It was not until 1888, with the development of the Maxim and its adoption by the Germans, that the possibilities of machine guns began to be appreciated.

In modern warfare, the extensive use of machine guns both in offensive and defensive action as an aid to the Infantry has been rendered possible by the application of fundamental principles derived from the following characteristics of the weapon.

The machine gun resembles the service rifle in calibre and range. It is both an infantry and cavalry weapon, and is used most effectively at their ranges.

Characteristics:

1. The rapid production of a large volume of sustained accurate fire in action.
 - (a) Based on the efficiency and training of soldiers and men.
 - (b) Surprise effect and sustained fire action must be preceded by careful preparation and reconnaissance. Enemy should be hit within five seconds after he appears—gun being properly sighted and aimed. Gun must be water cooled to permit of firing "rapid" for long periods of time.
 - (c) Sustained fire and proven reliability, allow reduction of infantry.
2. Fixed mounting or tripod.
 - (a) Reduces personal factor.
 - (b) Small shot groups.
 - (1) Good observation.
 - (2) Ease of control.
 - (3) Reliability.
 - (4) Accurate ranges necessary—5 per cent. for overhead fire.
 - (5) Enfilade or oblique fire—indicated by (b).
 - (c) Makes night firing and both direct and indirect overhead fire possible.
 - (1) Close support of infantry.
3. Narrow front and shallow depth.
 - (a) One gun equivalent to from 30 to 60 rifles, depending on position.
 - (b) Can hold large front from small position.
 - (c) Can take advantage of small and isolated cover.
 - (d) Fire control easy.
4. All around traverse.
 - (a) Indicates employment from flanks.
 - (b) Necessary to limit traverse to safety limits—(stakes or loophole)—so that this characteristic is at once an advantage and a disadvantage.
5. Invisibility and Invulnerability.
 - (a) Consider position a line, not a point, and conceal (camouflage when necessary) communication as well as gun emplacement.
 - (b) Gun position well concealed, difficult to locate and demolish.
 - (c) Two men required to operate gun—takes little movement. Bringing into position and supplying gun does require movement. Choose emplacement and approach easily concealed, when possible.

- (d) May lose 75 per cent. of crew and not reduce fire power, if you have ammunition. This is not true of infantry.
 - (e) Must have reserve man power to replace casualties. Barrage fire is only exception to two men at gun.
 - (f) Personnel—highly trained in use of ground and cover.
 - (1) Artillery and 37 m.m. gun chief enemy of machine guns.
 - (2) Men on supply line must be well trained—dangerous duty, great responsibility.
6. Mobility:
 - (a) Term is comparative—if mounted faster; if dismounted, slower than infantry.
 - (b) Extensively used in advance and rear guard work—Motor M. G.'s last to withdraw.
 - (c) Tactically M. G.'s are a reserve of fire power.
 - (1) Should avoid frequent moves, and should only move to—
 - (a) Give infantry closer support.
 - (b) Consolidate captured ground.
 - (c) Avoid shell fire.
 7. Unavoidable Characteristics.
 - (1) Stoppage due to accident.
 - (a) Proper care of gun in care and cleaning and usage will minimize this danger.
 - (b) Teach thoroughly I. A. and cures for jams.
 - (c) Careful selection of spare parts.
 - (2) Noise of firing—steam and oil vapor. Flash.
 - (a) Cannot overcome noise, but when other guns are firing, it is hard to locate a machine gun by noise.
 - (b) Steam—counteracted by condenser and steam tubes.
 - (c) Oil vapor—important to guard against this. Before firing, dry bore and muzzle attachment, and use no more oil on lock and recoiling portions than is necessary. Wet sandbags on ground will prevent muzzle blast from raising dust and darkening the earth.
 - (d) Flash—plain at night and in dull weather. Means of concealment:
 - (1) Flash protectors—unsuccessful.
 - (2) Wet screens 14 yards in front of gun, behind A. A. M.
 - (3) Flash deflated by properly constructed loophole.

NOTE: If position is detected, only safe way is to move at once to alternate emplacement.

 - (3) Amount of ammunition expended.
 - (a) The S. A. A. with gun may be quickly exhausted, which necessitates supplying gun from dumps in rear. Officers must keep this question ever in mind, and if necessary, provide parties to bring up ammunition and water.
 - (1) Need strong intelligent men, well trained for this work.
 - (b) Belts emptied quickly.
 - (1) Men must be experts in machine and hand belt filling.

THEORY OF FIRE.

FORCES ACTING ON THE BULLET.

- Explosion. Drives bullet from muzzle, 2700 feet per second, 70° F.
- Grooves or rifling, cause twist, resulting in drift, small at mid ranges amounts to 2 mils at approx. 2000 meters. This is corrected approx. by drift slide on tangent sight.
- Explosive effect of bullet: Bullet rotates on long axis to left. Up to 500 yards—wabbles—tearing effect—500—1200 travels true, clean hole. Over 1200 again rocks—until it tumbles—tearing effect again.
- Gun tested for 4500 yards—vel. 480 feet per second.
- Air resistance: Reduces velocity, winds effect both direction and elevation.
- Gravity exerts constant pull.
- Gravity and air resistance cause curved path or trajectory and effect time of flight.

FIRE DIRECTION I.

- Fire direction may be defined as being the selection and application of the best method of engaging any given target in conformity with the tactical situation.

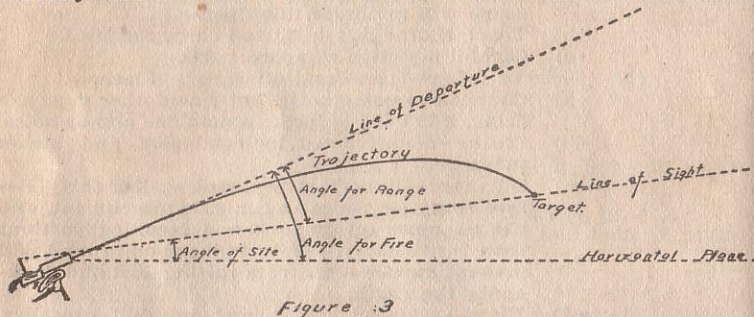


Figure 3

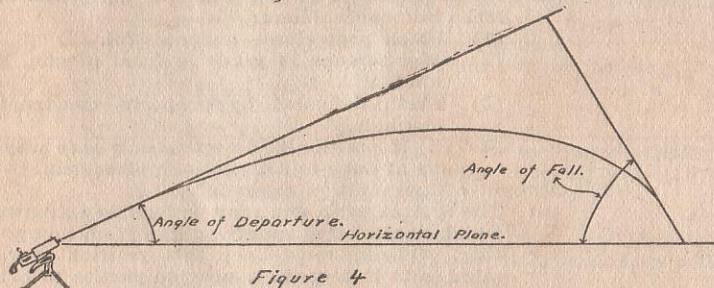


Figure 4

- The line of sight is an imaginary line passing through the point where aim is taken.
- The angle of site is the angle between the line of sight and a horizontal plane. This angle may be either positive or negative.
- The angle for range or the angle of tangent elevation is the angle between the axis of the bore and the line of sight.

5. The angle for fire or the angle of quadrant elevation is the angle between the axis of the bore and the horizontal plane. May be either positive or negative.

6. Angle of fall is angle formed between the tangent to the trajectory and line of sight at the point of strike.

7. The trajectory is the path of the bullet through the air. The highest point in the trajectory is called the summit, approximately 57/100 of range.

8. The mean trajectory is a trajectory that would hit the exact center of shot group.

9. The first catch is the point where the lowest bullet strikes the ground. The distance between the first catch and the first graze is the dangerous space.

10. The danger zone is between the first catch of lowest shot and the first graze of highest bullet.

11. The Beaten zone is the surface of the earth struck by the cone of fire produced by the whole series of fire and not by a single burst. Best 75 per cent. of B. Z. is called EFFECTIVE BEATEN ZONE (E. B. Z.). Best 50 per cent. is called nucleus.

TABLE.

Approximate E. B. Z. U. S. Ammunition (75%).

500 meters	118 meters	2½ feet
1000 meters	62.6 meters	5 feet
1500 meters	52.3 meters	10 feet
2000 meters	59.7 meters	20 feet

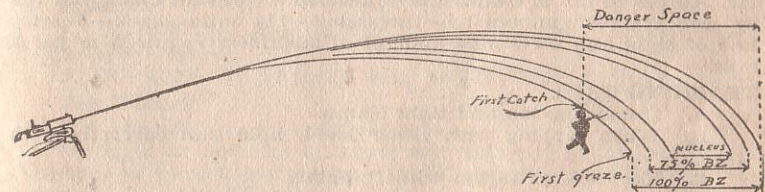


Fig. 5.

APPLICATION OF FIRE.

Fire applied in burst or groups, the number of shots per burst varies according to the range, target and class of fire desired. Fairly large burst for deep targets. Short bursts for shallow wide targets.

Forces acting on bullet are: Explosion, air resistance, gravity difference in ammunition (weight and size of charge), wear of barrel, vibration of gun, worn mount, bad holding.

See tables in appendix for corrections for error of the moment.

Aiming Off for Movement Table.

Range.	Man Walking.	Man Running.	Horse Trotting.	Horse Galloping.
Per 100 meters	1 ft.	2 ft.	3 ft.	4 ft.

RESULTS OF EXPERIMENTS.

- Hot barrels make no effect.
- New barrels cause angles of departure to be too great. Over shoot 150 yards up to 2000.
- Weather condition found to have most effect especially
- After 20,000 rds. bullet drops short 5 per cent. of range.
- Rainstorms causes bullets to fly high.

KINDS OF FIRE.

FIXED FIRE.

- A. Fire directed at object of such size that it may be covered effectively by the fire of a single cone.
- B. It is the ordinary fire used when firing at a single aiming mark. Soldiers must practice to make cone small.
- C. Must learn zero of M. G. to be able to correct for range. (Ref. P. A. 122 M. G. M.)
- D. Used in bands of fire.

TRAVERSING FIRE.

- A. To engage a linear target, parallel to our front.

TAP TRAVERSING.

- A. Distribution of fire in direction of width—used in series of burst—object to cover target in such a manner as to get best results with minimum expenditure of ammunition. Fired in bursts normally 5—10 using 2 mil taps—if target is dense size may vary.
- B. Chief disadvantage of using tap traverse is that great amount of time is required to cover given fronts.

Remedy: Place gun so as to get oblique (enfilade) fire, so cones will cover large part of target, and put smaller number of shots into intervals of target.

- C. To get shot groups at normal intervals requires much training to acquire two mil tap. Untrained men apt to become excited and traverse more than two mils—leaving gaps. Enemy may easily anticipate where next group may fall. This can be avoided etc. Object of tap in training is to develop a constant change in the by well trained gunners by—traversing—7½ mils—back—5 mils, line of sight and determine amount of stickiness required to get 2 mils.

TEACHING TAPS.

- A. Use strong tap and tight clamp.
- B. When tapping with either hand, hold gun correctly with other.
- C. Keep eye on target while tapping.
- D. If gun moves too much or too little, change clamp, never change weight of tap.
- E. When testing for stickiness use sights.

SWINGING TRAVERSE.

- A. Carry hands to right or left.
- B. Used only at massed targets and at short ranges—400 yards normal rate—30 yards in 5 seconds.
- C. Traversing is to cover target—too fast—wast ammunition.
- D. Is occasionally used at skirmishers rushing.

SEARCHING FIRE.

- A. Distribution of fire in direction of depth.
- B. To cover a deep target or overcome error in ranging.
- C. If not sure of range with one gun—search—with two guns combined sights.
- D. Size of bursts depends on nature of target. Usually larger than in traversing. Deeper targets.
- E. Amount of search is 2 mils (taught on 1000" range). Gunner should practice constantly. Turn wheel boldly with short, sharp turns.
- F. When turning wheel keep eye on target, turn wheel with right hand only.
- G. Searching will be discontinued after observation of results has been obtained.

OBLIQUE TRAVERSING.

- A. Firing at a line at an angle to your front.
- B. To cover: Fire, tap, elevate (or depress). In this fire it is necessary to use sight as 2 mil search is not always used.

COMBINED SIGHTS.

- A. Two or more guns are used to increase depth of B. Z. by using different elevations and same aiming marks.
- B. Ensure fire covers large zone but reduces intensity of fire at any particular point.
- C. Differences of elevation depend on number of guns. After considering Probable Error and E. B. Z. of each gun for range assigned to it.
- D. Should be distributed so that each E. B. Z. touches.
- E. In using this class of fire all officers should know E. B. Z. for all ranges so as to get maximum effect. See table.

FIRE DIRECTION II.

Permissible error ¼ depth of beaten zone.

Elevation of 2 mils gives an overlap of E. B. Z. at all ranges (not true of taps).

Searching fire with one gun—search within limits that will ensure covering probable error in ranging.

Example:

1. R—900—by estimate P. E.—15 per cent. or 175 meters i. e., 270 meters to search.
2. R—1000—10 per cent. error or 200 meters to search.

Fire Order:

900. Target—to 1100 searching fire.

Set sight at 900 aim at target and without changing quadrant elevation of barrel, set sights at 1100 and search until again on target.

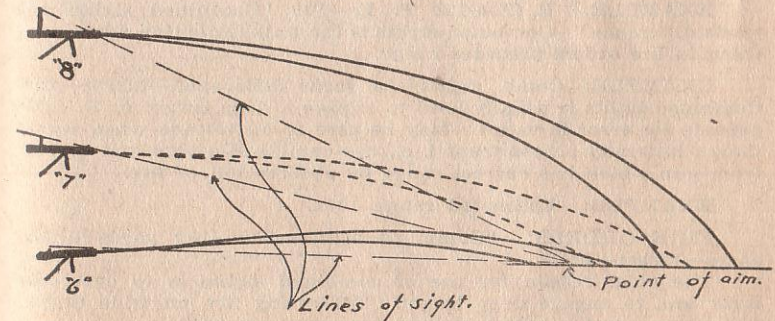


Fig. 6.-7.-8.

The above method is for covering a point or M. G. emplacement where range is not accurately known.

When it is desired to cover a deep target with one gun proceed as follows:

Target 1050 to 1350, 10 per cent. error.

Set sights at 950 and lay on near edge, then set 1500 on sights and search to far edge (estimate 1350),

Fire order should state size of bursts i. e. 950—Near edge to 1500 far edge—target—bursts of—searching—Fire.

If target has depth and width—large bursts—30—50. This type of searching fire is for taking on deep targets and for overcoming effects of sloping ground—column of squads coming down a hill, etc. First method given might be used for engaging a shallow target—a point—etc.

To increase range by 100 meters or yards: (Rough Rule.)

From 0—1000 2—2 mil turn.
1000—2000 3—2 mil turn.
2000—2500 4—2 mil turn.

To convert yards to meters or reverse—add or deduct one-tenth (rough rule).

Guide for Traversing.

Guns	1	2	3	4
4	Rt	Rc	Lc	L
3	Rt	C	L	
2	R	L		

COMBINED SIGHTS—Method of engaging a target by employing simultaneously, overlapping zones of fire from two or more guns.

Give advantage of surprise effect.

Guide—Use 100 meters diff. when P. E. is great.

Use 50 meters diff. when P. E. is small.

Use as many guns as possible (not elevations).

If E. B. Z. of gun for given range will cover a distance greater than P. E. in this class of fire use 100 yards difference even if error is small.

EXAMPLE: B. Z.—150 P. E.—100 "Combined sights 100 yards difference." Combined sights is the only exception when anything in fire orders precedes range.

EXAMPLE: Comb. sights—50 yards difference—target—fire. Combined sights is usually used to engage a deep target or to compensate for error in range. May be used to advantage when target moves laterally across front i. e., use combined sights and correct from gun which has correct range by observation of fire.

EXAMPLE: Estimated range 1000.

FIRE ORDERS: "Combined sights—800—100 yards differences—target—fire!"

The chief reason for use of combined sights is to overcome error and to engage deep target. Traversing fire on wide target, and when target is both wide and deep may use both.

SWINGING TRAVERSE. Not used often. Massed target, at short range. Rate 30 yards in 5 seconds. Bursts of 150 to 200 rounds.

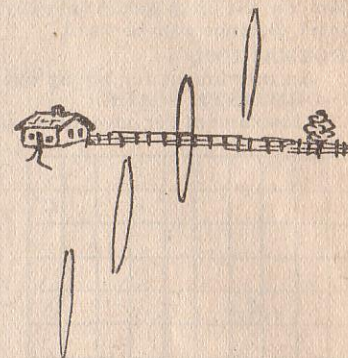
Opportunity for using oblique traverse should be sought. Gunners are taught to observe and correct fire, except in Figure 9.

COMBINED SIGHTS ILLUSTRATIONS.



III
G.

Fig. 9



IIII
G

Fig. 10.

THE USE OF MAPS AND INSTRUMENTS.

SCALE.

An instrument for laying out exact distance.

The smallest constant unit of our own scale is the inch—this may be divided into tenths, twentieths, thirtieths, fortieths, fiftieths, sixtieths, eightieths, or hundredths.

COMPASS (COMPASS DIVIDER).

An instrument for dividing lines.

This instrument is adjustable, and can be set so that its index points exactly include two positions on a map and then by placing them on the map scale (usually printed with the map) the horizontal distance can be read.

PROTRACTOR.

An instrument for laying out and measuring angles on paper.

CO-ORDINATE SCALE.

An instrument for measuring the co-ordinate on a square map.

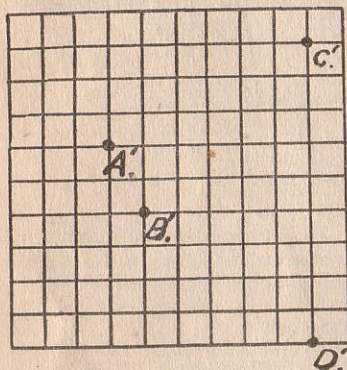


Fig. 32.

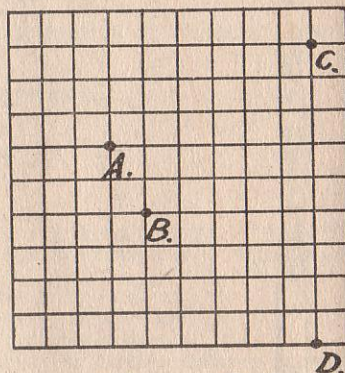


Fig. 33.

APPLICATION.

Assume the co-ordinate scale (Fig. 32) to be the same size as the square kilometer.

FIGURE 33.

By placing the scale, which is transparent, on the map so that the outside lines of each coincide: The co-ordinates for the points will appear as A', B', C' and D' (Fig. 32), and D' in (Fig. 33). First read the vertical and then the horizontal co-ordinate: A' will read 3 and 6 or 36—B' 44—C' 99—D' 09.

MAGNETIC NEEDLE.

An instrument for determining the direction toward one of the earth's magnetic poles.

The vertical plane passing through the needle and the magnetic north is known as the magnetic meridian. This meridian changes through a cycle of years and also from day to day.

The daily variation is about eight minutes, and the deflection from the true north is least about 1½ hours before noon.

Location attractions, natural or artificial, also cause a deflection of the needle from the magnetic NORTH.

The magnetic needle used in connection with a graduated dial is called a compass. There are several types, but the principles of each are the same.

The compass enables the reading of the magnetic bearing to any object.

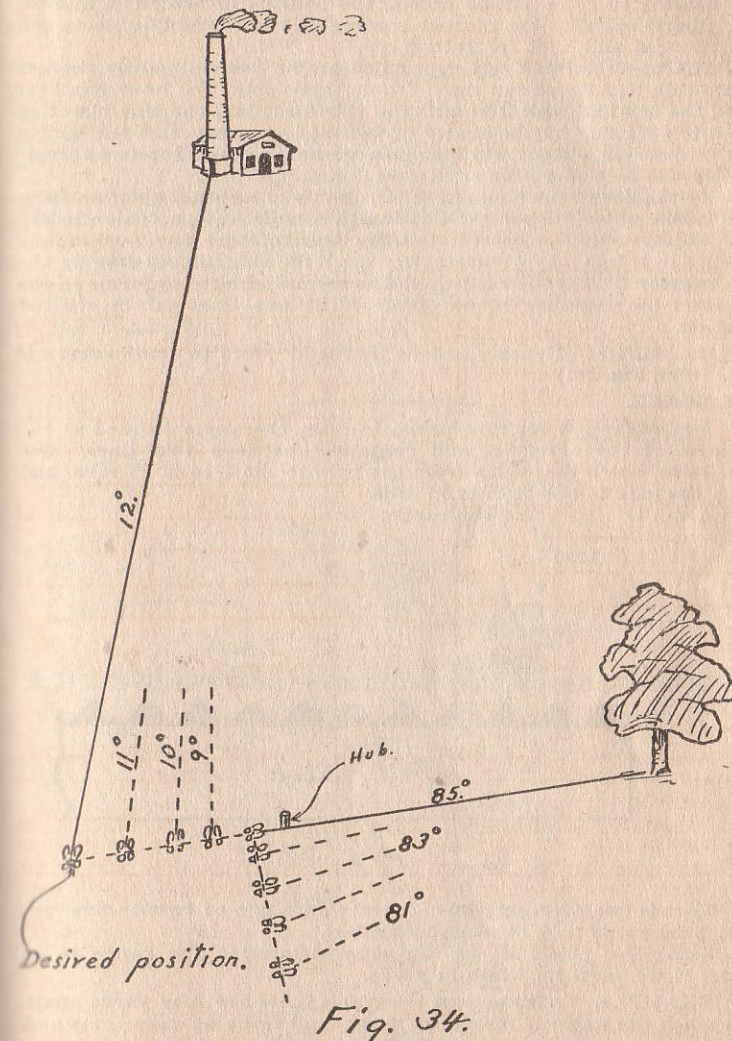


Fig. 34.

The angle that the magnetic meridian or the direction of the needle is making with the true meridian is called the **declination of the needle**. When the declination is known the true bearing of a line can be determined.

The declination of a needle has different values in different localities and they also give the yearly variation of the isogonic lines.

Local attraction of the needle often makes the reading very inaccurate so that it will frequently be advisable to check by taking the bearing to some visible object, the bearing of which is known.

Charts showing the correct bearing to these visible objects can be prepared and kept for reference.

The true meridian can approximately be determined by the use of a watch that keeps sun time: To do this—point the hour hand toward the sun and with it pointing in this direction, the line bisecting the angle formed by the center of the dial—sun ray and the center of the dial—12 o'clock ray lies in a vertical plane that is approximately the true meridian.

By the use of the compass it is possible to locate a position from two visible objects when the bearing to each is known. Line in the first object with the correct bearing and indicate the position by driving in a hub, then move along the hub—first object line or the line projected until the reading to the second object conforms to the required bearing—the intersection of the two lines is the desired position.

EXAMPLE: Bearing to lone tree is 85° , and to smoke stack is 12° . (See Fig. 34.)

MIL SCALE.

An instrument for measuring, in mils, the angle formed at the position of the observer, and contained between two lines. See Fig. 35 in which the width from the gate to the tree is 23 mils, and from the gate to the bush is 75 mils.

A mil is 1 of the range:

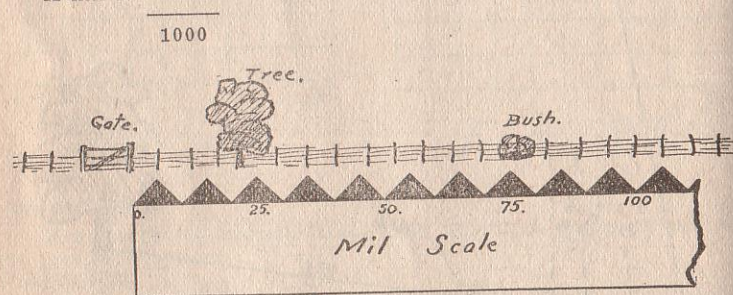


Fig. 35.

That is two diverging lines contain an angle of twenty-five mils if at 1000 yards they are 25 yards apart. Using this principle we can often determine the range to an object if we know its width in yards.

EXAMPLE: Assume two telegraph poles are fifty yards apart, and when the angle is measured it is found to be 40 mils; in which case the value of one mil would be 50 yards, or 1.25 yards—then

40

by multiplying 1.25 by 1000 we find the range to the poles to be 1250 yards.

From the above we deduct the following formula:

$$W \ 1,000 = R$$

M

W=Width=50 yards

M=Mils=40

R=Range=1250 yards.

* * * *

Inverted sight leaf or graticule. An instrument for correcting the range.

Let us assume that we had a target exactly 1400 yards away and the firer at the gun could not see it on account of a fold in the ground, however, an observer standing at the gun position could; but both, at the same time, could see the base of a tree immediately above but on a hill some distance back the observer would hold the graticule so that the 1400 yard graduation cuts the target and with it held in this position finds that the base of the tree is cut by the 800 yard graduation.

He could then direct the firer to lay on the base of the tree with 800 yard setting and upon firing would hit the target.

See Figure 36.

* * * *

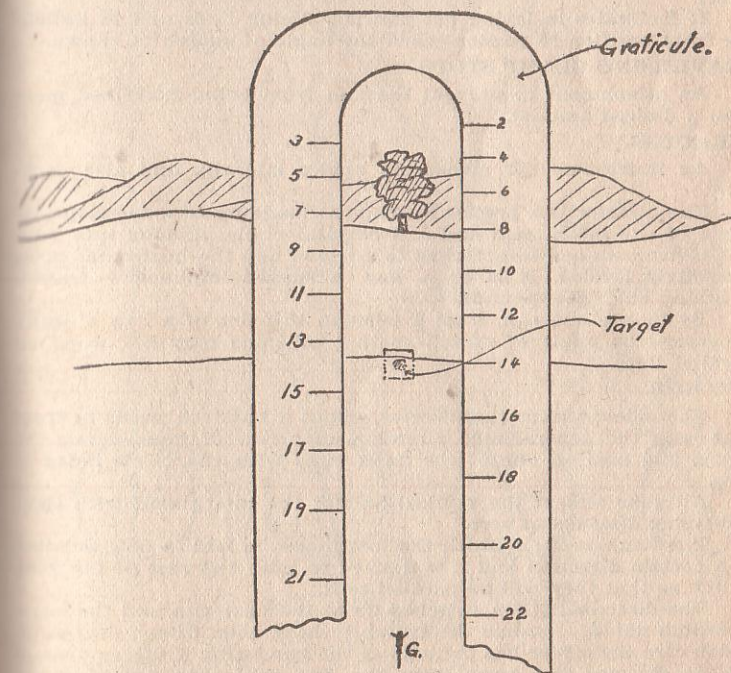


Fig. 36

ANGLE OF SITE INSTRUMENT.

An instrument for measuring the angle contained between the target gun line and a line in a horizontal plane through the gun position.

The angle of site instrument is graduated so the angle can be measured in mils.

CLINOMETER.

An instrument for measuring slopes.

In the military service it is used to give a gun a required elevation or depression and, like the angle of site instrument, is graduated in mils. It can be set so as to be used as a spirit level.

ELEVATING DIAL.

An instrument for registering the angle through which a gun is elevated or depressed.

It is attached to the elevating gear and divided into the same number of graduations that one complete turn of the elevating wheel effects, in mils, the setting of the gun.

TRAVERSING DIAL.

An instrument for registering the angle through which a gun is switched, in a lateral direction on a vertical axis. It is divided into 640 equal graduations of ten mils each (Artillery mil graduation.)

It facilitates in laying out parallel aiming lines and in switching from position to position when the angle of switch is known.

TRAVERSING CLAMP STOPS.

An attachment to prevent the gun from being traversed more than a desired amount.

DIRECTOR.

An instrument for measuring angles laterally and also vertically.

The director is a precise instrument made up of a telescope, an angle of site instrument and a horizontal circle, divided into mils. The instrument can be attached to a tripod and the horizontal circle accurately leveled. It is, in a way a rugged engineer's transit, weighing but a few pounds.

By its use one can, from a position in front of a row of guns, supervise the angle of switch so that all guns may be swung on parallel lines.

METHOD.

The officer places the director, about a hundred yards in front that is in the general zero direction, of a row of guns, levels the circle, and lays on one of the flank guns with the circle index at zero.

All guns aim at the vertical axis of the instrument with their traversing dials set at zero.

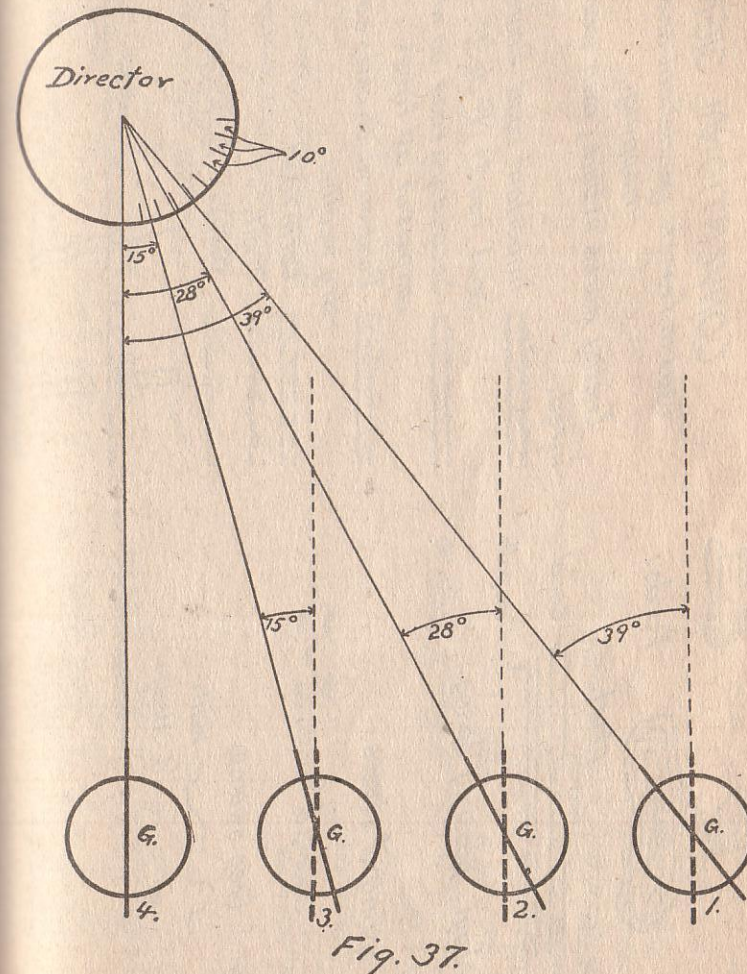
The flank gun, on which the instrument is laid is now pointing in a certain direction and it is desired to have the rest of the guns switch so that they will be parallel to it.

The director is then switched on to the next gun and the angle of switch noted. Assume the switch to have been fifteen degrees in which case the officer has the man at the gun swing it fifteen degrees off the director and away from the first gun, then assuming the switch, of the director, to be twenty-eight degrees when laid on the next gun in line, the officer will direct that this gun be switched twenty-eight degrees off the director and also away from the first gun.

This brings the three guns in each position that they are now laying on parallel lines: If there are other guns they would be located in the same way.

The director can then be placed directly behind one of the guns and used to give the amount of switch for the battery to engage different targets that can be picked up by using it.

See Figure 37.



RESECTION.

Method of locating your position on the map or making the map position conform to your position on the ground.

There are several methods given by any good work on plane table surveying, one of which is given here:



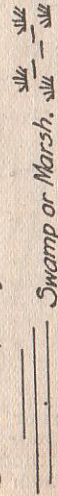
Ponds.



△ Fountain, possibly spring.



○... Spring of rivers.



Swamp or Marsh.



Deep swamp.



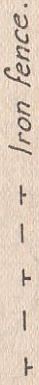
Wall.



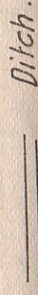
Hedge.



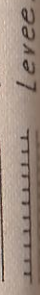
Wooden fence.



Iron fence.



Ditch.



Levee.

CONVENTIONAL SIGNS

used in French geodetical and military mapping.

Enemy works in blue; own work, when shown, in red.

—— Important road. Route Nat^{le} (National road) No deth b.

—— Secondary road on which traffic can pass at all times.

—— Road on which carts can drive in dry weather.

—— Farm road.

—— Trail.

—— Pistes = Foot path.



Railroad track.

--- Abandoned trenches.

E German battery by observation or photo.

" " " report.

Indicated underground work D^{ie} Cas^{ee}, D^{ie} Com^{ee}.

① Artillery

☼ Shell holes.



Organized work

xxxxxx Entanglement.

||||| Abette of all kinds.

□ Dug outs.

••••• Pit falls in front of trench. Troux de

Loup = Hole of wolf.

○ Ob. Observation post.

□ P. Post command.

△ M. Machine gun emplacement.

δ B. Trench mortar.

✠ CR. Revolver gun.

ψ Isolated gun.

— R.R. normal in black.

++++ Military RR, narrow track.

French works in red.

Black Red Advanced line.

Principal fire trench.

Communication trench.

Secondary communication trench.

Abandoned trench.



Village.

- Church on geodetic map has point in circle.
- + Prayer station, military Prayer sta. geodetic.
- ⊙ " chapel " " chapel "
- ⊕ Cemetery.
- ⊙ Wind mill, geodetic.
- ⊙ Watermill, military.
- ⊙ Geodetic point.
- ⊙ Chimney of factory.



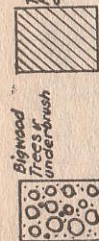
Farms limit.



Vineyard.



Garden & Orchard.



Blowdown trees & underbrush.



Trees in wood have been cut.

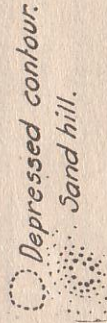


Pine wood shrubs.

..... Isolated trees.



Contours & number of hill.



Depressed contour. Sand hill.

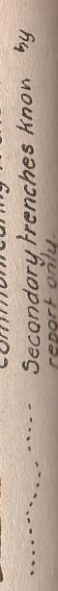
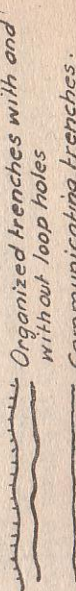
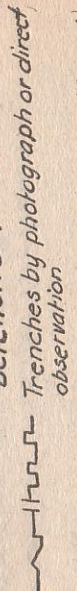


Natural cut. Rocky cliff.



Quarry.

Defensive work.



THREE POINT METHOD.

Set the plane table up at a point from which three objects, also shown on your map, can be seen; place a sheet of transparent paper on your table and from a point on it draw three rays (without moving the paper) in the direction of the three visible objects. Having done this, place the transparent paper over your map so that the rays fall on their corresponding objects: The point of intersection of the three lines will be over the correct map position.

EFFECT OF GROUND SLOPE ON M. G. FIRE.

It is evident that when the cone of fire from a machine gun falls on the forward slope of a hill, the length of the beaten zone is decreased and that when it falls on a far (or reverse) slope it is increased. This fact has a bearing on certain forms of fire. The extent of the increase or decrease may be easily determined.

When the forward slope is at right angles to the trajectory, the beaten zone is at its minimum, and at its maximum when the reverse slope is parallel to the trajectory.

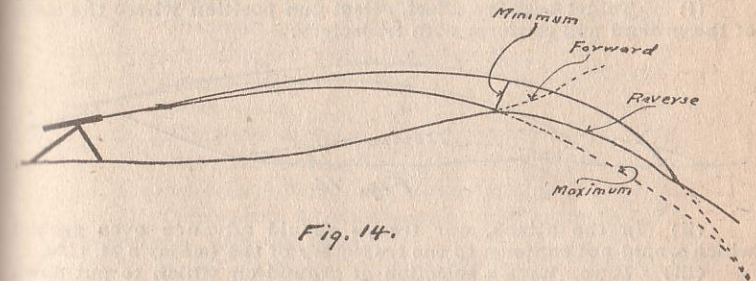


Fig. 14.

How much does the slope of ground effect the beaten zone. Letter A be the angle of fall of the bullet. Letter S be the angle of slope. Letter b be length of beaten zone on horizontal. Letter B be length of the beaten zone on the slope.

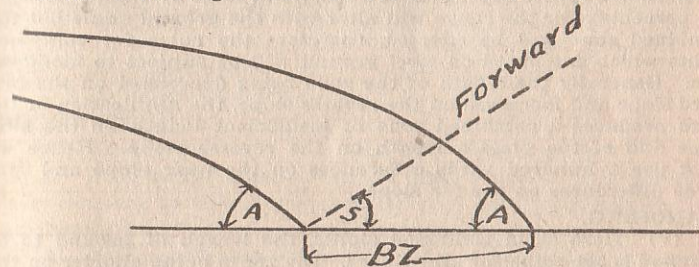


Fig. 15.

Then:

$$(i) \quad \frac{B}{b} = \frac{A}{A+S} \quad (\text{for a forward slope})$$

$$\text{or} \quad B = \frac{A b}{A+S}$$

$$(ii) \frac{B}{b} = \frac{A}{A-S} \text{ (for a reverse slope)}$$

$$\text{or } B = \frac{A b}{A-S}$$

EXAMPLE: Range is 1700 yards.

75 per cent. beaten zone=Aprox. 70 yards.

Angle of fall at 1700 yards=Aprox. 82 mils.

Slope has a fall 5 yards per hundred.

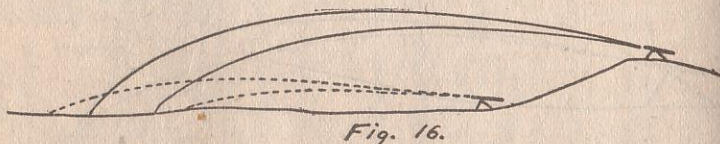
To find angle of slope in mils: 5 yards in 100=1 in 20.

$1/20 \times 50 = 50$ mils, angle of slope.

For a forward Slope: $B = 82 \times 70 = 5740 = \text{Aprox. } 43.5 \text{ yds. E.B.Z.}$
 $82 - 50 \quad 32$

A FEW PRACTICAL DEDUCTIONS.

- (i) To get best fire effect, select gun position where the slope of the ground will conform with trajectory.



(ii) In the attack, our troops should advance over ground which would not conform to the trajectory of the enemy's M. G.'s.

(iii) If you have a selection of ground on which to put down a barrage, do not put it on a forward slope. The efficacy of a barrage depends on its depth and the time taken to walk through it.

WITH COMBINED SIGHTS.

(iv) In combined sights we have to produce an enlarged zone, which shall be twice as long as a certain percentage of range. Neither the percentage or the range will alter with the ground angle but the combined zone will be effected, therefore the rules for combined sights which are based on level ground will be subject to modification. Generally the length of the zone being decreased on the forward slope and increased on the reverse slope, the application of the rules produces a combined zone of insufficient length on the near slope and of too great a length on the reverse slope. Hence we must use a hundred yards differences on the near slope and fifty yards differences on the far slope.

SEARCHING.

(v) Here as in combined sights, the length of ground to be searched is the same for all—slopes. The zones being shorter on the forward slope, we will require more of them. In other words the difference between the original and the final elevations ordered for the guns must be greater and vice versa for a reverse slope. Therefore, for a near slope the range for the near limit should be reduced by a hundred yards and the far limit by the same amount. For the reverse slopes the near limit as calculated in ordinary methods for searching may be increased by a 100 yards and for the far limit decreased by 100 yards.

On reverse slopes searching will be restricted.

SEARCHING REVERSE SLOPES.

- (vi) For rules for the searching of reverse slopes see table 1.

INDIRECT FIRE.

DEFINITION.

Indirect fire is that fire obtained by any other means than by laying it over the sights on to the target.

INSTRUMENTS USED:

Clinometer, spirit level, direction dial, inverted sight.

An A. A. M. is any aiming mark other than the target which the gunner uses for putting on and maintaining direction and elevation.

A target may be invisible due to:

1. Darkness.
2. Smoke.
3. Fog.
4. Rain.
5. Obstacles.

Direction is obtained first, then elevation.

Direction is put on by:

1. Posts alone.
2. Posts and compass.
3. Compass tower.
4. Reference object and direction dial.
5. Compass in front of gun.

Direction is maintained by:

1. A. A. marks.
2. Direction dial.

Elevation is put on by:

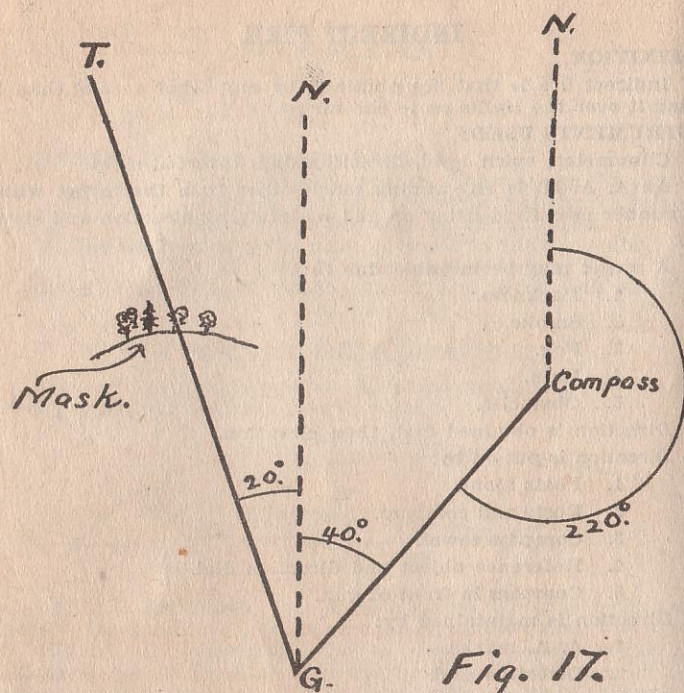
1. Clinometer.
2. Tangent sight and spirit level.

Elevation is maintained by:

1. A. A. mark. (T shaped and night firing box.)
2. Clinometer.
3. Elevation dial.

DIRECTION.

1. Posts alone must be in line with target and gun.
2. **Post and Compass**—Set six inch stake on gun position—place compass on this stake—turn compass until the needle points at the desired bearing. Set one or two posts on this line.
3. **Compass Tower**—Mount tripod in position and fit tower on it. Turn crosshead until you get the required bearing, then clamp it. Zero direction dial or take reading if not rotatable.
4. **Reference Object and Direction Dial**—On map draw light lines to reference object and target from the gun position. Measure angle. Lay gun on reference object and turn through the angle read on map.
5. **Compass in Front of Gun**—Get bearing of target from gun (from map). Bearing of gun from compass position. Lay gun on compass position and swing through required angle.



$220^\circ - 180^\circ = 40^\circ$ (will lay gun in MagN)
 $40^\circ + 60^\circ = 60^\circ$ Angle gun is to be swung through from
 compass to target.
ELEVATION.

TANGENT SIGHT AND SPIRIT LEVEL METHOD.

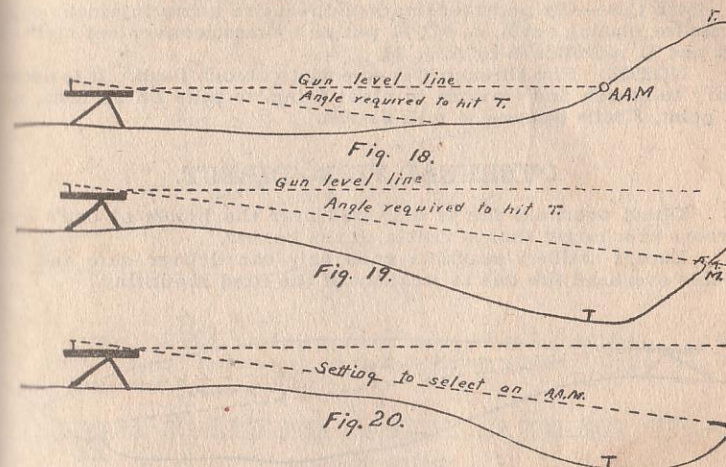
Four possible cases may occur:

- Angle of Q. E. positive and A. A. M. seen or put out.
- Angle of Q. E. negative and A. A. M. seen or put out.
- Angle of Q. E. positive but A. A. M. cannot be seen or put out.
- Angle of Q. E. negative but A. A. M. cannot be seen or put out.

Procedure:

- No. 1 takes holding—level gun with spirit level—set sights at zero and pick out or put out an A. A. M. not nearer than 100 yards—set sight at range corresponding to Q. E. and relay on A. A. M.
- Level gun as above—set sight to range required by Q. E., pick up or put out A. A. M. as above—set sights at zero—relay on A. A. M.
- Level gun as above—set sight at zero—cannot see or put out an A. A. M.—run sight up till an A. A. M. can be seen—convert range now shown on sights to an angle of Q. E. and add this angle to the original Q. E. required. Place sight to correspond to this total angle and relay on A. A. M.

- Level gun as above—sight at zero—no A. A. M. can be seen or put out—run up sight and find an A. A. M.—convert range shown to an angle of Q. E. and subtract the Q. E. originally required from this new angle. Convert the result into range and relay.



CONSIDERATIONS GOVERNING INDIRECT FIRE.

- Safety of own troops; must know position of our own troops at every moment during advance; work on a time table. (See safety clearances.)
- Effect on enemy, great moral effect, and valuable harassing fire. Don't mind retaliation.
- Supply of ammunition.
- Obtain observation if possible. Fire must be accurate. (For details see Part II, No. 8. Maps and instruments.)

NIGHT FIRING.

(Ref. M. G. F. M.)

- Gun brought up by day and laid on target.
- Brought up and laid by day, removed for other work and returned at night. (Not often used.)
- Brought up into position for first time, by night and laid in dark.
- Arrival at position at night for first time.
BY DAY: Range to target laid on target and left. Put a sentry over the gun to ensure that it is not touched.
BY NIGHT: 1st Case—Send out a luminous A. M. Adjust tangent sight and position of A. M. until the sights are aligned on it. Make any change necessary for errors of moment.
 2nd Case—Laid by day; posts set up, mark height and exact position of tripod legs, lay on A. A. M., level, and note sight setting. Remove gun. At night erect tripod in exact position, level gun, put sights to proper range, lay on A. A. M.

3rd Case—By day, drive in 6" stake at G. P. Put in a second peg to give direction. Lay by compass if peg is not visible. Obtain angle of Q. E. By night mount tripod over peg at G. P. Replace the front peg by a luminous A. M. Put on Q. E. by most convenient method. Maintain E. and D. by the A. A. M.

4th Case—By night, ordinary indirect fire using luminous compass for placing out A. A. M., E. put on by most convenient method. E. and D. maintained by A. A. M.

NOTES: Fire through wet screens to absorb flash. It is necessary to search and traverse in night firing, to take on an area, not a point, 8 mils traverse, 4 mils search.

OVERHEAD FIRE—DIRECT.

Direct overhead fire is delivered over the heads of one's own troops at a target that is visible to the gunner.

Except artillery machine guns only can deliver safe and reliable overhead fire due to stability of the fixed mounting.

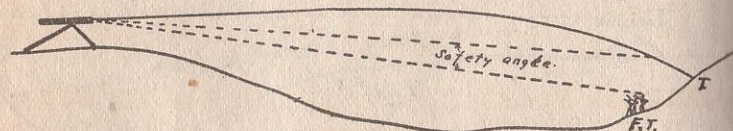


Fig. 11.

GENERAL RULES GOVERNING DIRECT OVERHEAD FIRE.

1. Overhead fire must be discontinued when friendly troops are more than 2000 yards from the guns.
2. Range to the target must be accurately known (within 5 per cent error).
3. Target must be clearly visible to the gunner.

Regarding the Gun.

1. Barrel and tripod must not be worn.
2. No. 1 must be a reliable gunner.
3. Tripod must be firmly fixed, and triangle bases used.
4. Ammunition must be good.

The time when guns open overhead fire depends entirely upon the tactical situation, and distance of own troops from guns and upon terrain.

The following rules are for general guidance:

1. Gun commanders must be prepared to continue fire by indirect overhead methods if observation is not available.
2. Depression stops should be used if possible.

In covering troops with overhead fire, firing from a command, the total clearance is greater than when firing to a command.

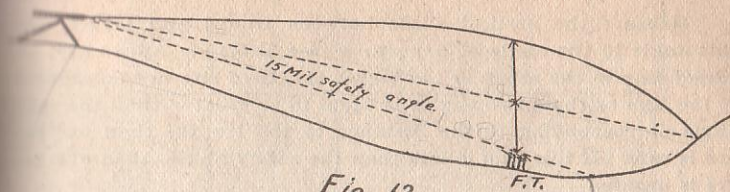


Fig. 12.

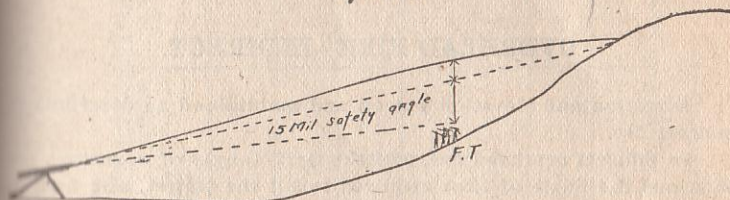


Fig. 13.

FIRE ORDER: (Specimen) 1000—trees....(caution) "Direct overhead" (set depression stops) "Safety limit, sight 1450—traversing—fire."

GENERAL RULES FOR SAFETY IN DIRECT OVERHEAD FIRE.

1. Our own troops must not be more than 2000 yards (1800 meters) from the gun.
2. The range to the target must be known to within 5%.
3. The barrel of the gun and the tripod must both be in good condition. A barrel which has fired more than 15000 rounds must not be used.
4. The tripod must be firmly fixed and legs anchored.
5. Target and troops must be clearly visible to gunner.
6. Ammunition must be reliable.
7. Depression stops must be used if possible and limits of traverse fixed.
8. Flash screens should be used when possible.
9. Prepare to continue fire by indirect means if observation becomes impossible.
10. In covering troops with overhead fire, firing from a command the total clearance is greater than when firing to a command. (See Figs. 12 and 13.)

PROCEDURE IN DIRECT OVERHEAD FIRE.

The gun is placed in position, the sight set at the correct elevation, and the gun then clamped in position. Without changing the elevation of the piece, the sight is then set at the "corresponding range" to the safety angle, as shown in Table—(Appendix. With the sight thus set, the point of aim is noted and if this point of aim is found to be at or above the feet of the troops, then overhead fire is safe. If the point of aim is found to fall below the feet of the troops, then overhead fire is unsafe.

If, for any reason, it is desired to solve the problem of troop safety without putting the gun in position, it can be done thus:

OVERHEAD FIRE—INDIRECT.

In indirect overhead fire, find the Q. E. (angle of departure plus or minus the angle of site) required to hit the target, and find the angle of site to the troops. If the algebraic difference between these two angles equals or exceeds the safety angle corresponding to distance to the troops, then overhead fire is safe. If this difference is less than the safety angle, then overhead fire is unsafe.

- (1) By tables (tables of ordinates for quadrant elevations for all ranges. (See Table C).
- (2) By graph.
- (3) Slide rules may be used to check calculations.

Angle of clearance = A - B (algebraic difference)

A=Q. E. in mils.

If result obtained exceeds or equals safety clearance from table—safe to fire.

Fig. 21.

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Fire Calculations Form—(Provisional)

(Indirect or indirect overhead fire)

All distances and contours in yards—meters
(*Grass: word not applicable*)

hours in yards—m

Organization

Date _____

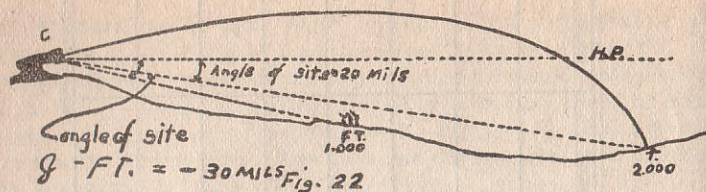
Map used

Officer in charge of firing—

[illegible]

NOTES: 1-Angle of clearance in mils=A-B.
2-Immediately before firing make allowance for climatic conditions.
3-If problem is clearance of mask only, then A must exceed the Quadrant Elevation to mask by one half the depth of the cone (in mils).

Form No. 218-5-21-18-1000



Q. E. pos., (A) angle of site to F. T. neg. (B)
Angle site to T = 20m.

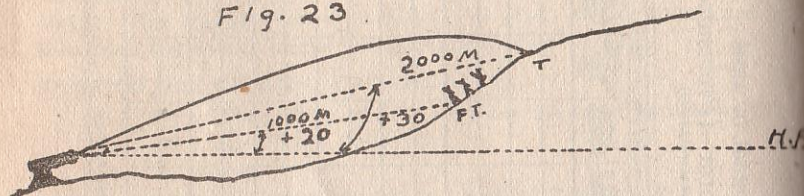
+68.3m (2000m)
Angle of departure =

Q. E. = +48.3 = (A)

Angle of site to F. T. = -30.

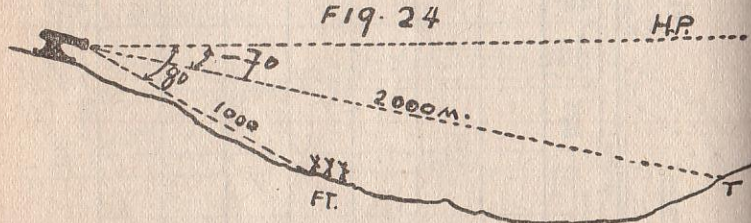
Algebraic difference = +78.3 = Total clearance.
Required clearance, at 1000 m = 36.5 = safe.

Fig. 23



Q. E. pos. (A) Angle of site to F. T. positive (B)
Angle site to T = 30 mils
Angle of departure = +68.3 mils (2000 m)
Q. E. = 98.3 mils
Angle of sit to F. T. = 20 mils
Algebraic difference = 78.3 mils
Required clearance at 1000m = 36.5 = safe.

Fig. 24



Q. E. Neg. (A) Angle of site to F. T. Neg. (B)
Angle of site to target = 70m.
Angle of departure = +68.3 mils (2000m)
Q. E. = -1.7 mils
Angle of site to F. T. = -80 mils.
Algebraic difference = 81.7 mils
Required clearance at 1000m = 36.5 = safe.

(B) Safety Precautions.

1. F. T. must be warned.
2. F. T. must not be more than 2000 yards from gun.
3. Steps must be taken to limit the extremes of traversing and searching, to keep within safety limits. Use depression and traversing stops if possible.
4. Gunner must lay accurately on A. A. M. and have steady holding.
5. Worn barrels and mountings must not be used.
6. Tripod firm; triangle base essential, and sand bags. If no base available, dig in.
(Sinking in of 1 inch by tripod leg causes variation of 25 mils in Q. E.)
7. All calculations independently checked.
(See specimen fire calculation forms.)
8. Error of the moment allowed for.
9. Flash to be concealed if not deflagged; usually by screens.
10. Mask clearance.

- (a) Compare QE to mask with QE to T. If QE to T greater than QE to mask (by Clearance Table D) mask will be cleared.
- (b) Rough Rule: Clearance 1000 and under = 2.6 mil.
Clearance 1000-2000 = 5 mil.
- (c) To test clearance with gun:
 - (1) Put QE to T on gun. Set T sight to zero (or 500). If line of site clears mask—OK.
 - (2) Put QE to T on gun, look through bore.
 - (3) Lay gun on T with correct elevation and direction. Set T sight to R to mask without changing bore—then if line of site clears mask, cone will clear mask.

NOTE: When gun is laid with correct QE, mask clearance can be determined by either looking through the barrel, or along outer casing on a line with the bore.

ANTI-AIRCRAFT WORK.

1. Tasks of air-planes.
 1. Artillery observation.
 2. Reconnaissance.
 3. Photography.
 4. Bombing.
 5. Protection squadron or battle squadron.
2. Air-planes come over trenches early in morning, in swarms reconnoiter and incidentally to photograph.
 1. This photograph must not be confused with specific work done prior to battle.
3. Suppose we have located general position of a hostile battery—flash, etc.
 1. Reconnaissance plane tries to spot it definitely—when located—by flash or otherwise.
 2. Second plane—will photograph.
4. Artillery observation—this means observing fire—and assisting to regulate battery.
5. The above mentioned all have "peaceful mission"—this is do not bomb, etc., and they must be protected by fighting planes—flying above them.

Enemy, of course, are engaged in same work.

How prevent enemy planes from coming over our front.

 1. Battle planes.
 2. Active counter measures from ground.

Air-planes are engaged from ground by—

 1. Anti-aircraft artillery.
 2. Machine guns.
 3. Automatic rifles.
 4. Rifles.

Counter measures from ground can never take place of counter measures from air.

1. Ground measures—have effect of—
 - (a) Seriously effecting enemy moral.
 - (b) Upsetting his plans.
 - (c) Sometimes bringing him down.

Aircraft machine guns same as regular M. G. with special mounting.

TASKS OF MACHINE GUNS.

1. Protection to Our First Line System.
 1. Enemy attack followed by contact plane.
 1. Low flying for communication with infantry.
 2. Must prevent them from working.
 3. Protect billets, villages—companies and all back areas.
 4. Protect our own barrage guns, etc.
 5. Protection from sausages (kite).

Air-plain Has Few Vulnerable Parts.

1. Must hit in vital parts to bring down.
2. Look to moral effect more than anything else.
 - (a) This effect is tremendous.
 - (b) Object achieved if we drive pilot off and prevent him observing.

Difficulties and How Overcome.

1. Difficult to determine distance from gun to target.

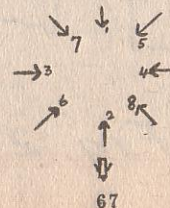
Range finder no use—move to fast.
2. Speed of machine—varies greatly—wind, etc.
3. Angle of sight—changes momentarily.
4. Wind—effecting both plane and bullet though not to same degree.

Distance.

1. Have two forces or functions to consider.
 1. Bullet traveling—2700 feet (initial).
 2. Machine traveling one-half mile in 15 seconds more or less.
2. Note from table length of time it takes bullet to travel required distance—but must relate time of flight to speed of machine, so that they will coincide, in other words, as in duck shooting—must estimate angle of lead.
3. As gun is elevated trajectory becomes flatter and finishes with a short hook (rocket).
4. As angle of site varies, so will trajectory.
5. Wind will sometimes hold plane almost steady, but will effect bullet to lesser degree.
 1. Must allow for that ratio.
6. Instruments cannot be used—time.
7. English have developed certain tables of allowances based on averages of the different conditions, and result is a compromise—which in practice gives good results.

(a) Table is simple and can be committed to memory.

1. Table is based primarily on altitude of plane instead of distance from gun to target.
2. Based also on probable factors—and a combination of averages, i. e.
 - (a) Speed of machine—average—in still air—80 miles per hour.
 - (b) Angle of site—50°—assuming that if angle is smaller—target too far away (ordinary angle of site for engaging 30°-70°).
 - (c) Length of line of sight—gun to T—900 yards based on assumption that plane is not higher than 3000'—average 2000'.
 - (d) Average direction of machine—8.



From these factors—following table has been worked out.
O. K. for U. S. Amm.

(See next table for more convenient method for U. S. Guns.)

English anti-aircraft sight gives correction automatically.

(a) Circular—celluloid disc. 5" D—on a bracket—with special front sight $1\frac{1}{8}$ " high.

As we have no such sight—should mark our rear sight with white lines, as per sketch which will then coincide with following table for use with our guns.

Remember there is nothing exact about this, merely a method which will give results.

DIRECTION OF FLIGHT

COMING	COMING AND CROSSING DIAG.		CROSSING		GOING AND CROSSING DIAG.		GOING
	elev.	def.	elev.	def.	elev.	def.	
$+4^{\circ} 15'$	$0+3^{\circ}$	3°	$+30'$	$4^{\circ} 20'$	$-2^{\circ} 30'$	$3^{\circ} 10'$	$-3^{\circ} 20'$

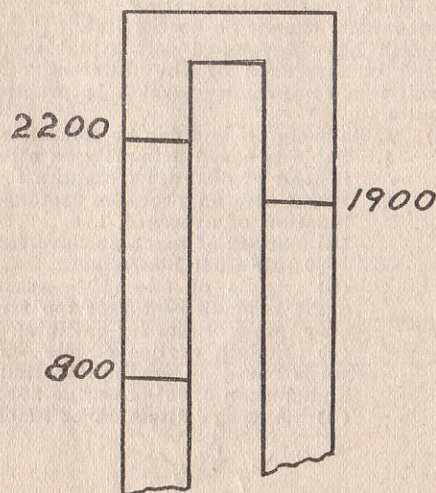


Fig. 29

Direction of flight	Sighting Elev.	Point of aim
Coming	2000	At plane
Coming and crossing diagonal	1900	$1\frac{1}{2}$ fingers, right or left, according to direction of flight
Crossing	800	2 fingers ft. of plane
Going and crossing diagonal	0	$1\frac{1}{2}$ fingers at 4:30 or 7:30 from center of plane
Going	0	$1\frac{1}{2}$ fingers below plane

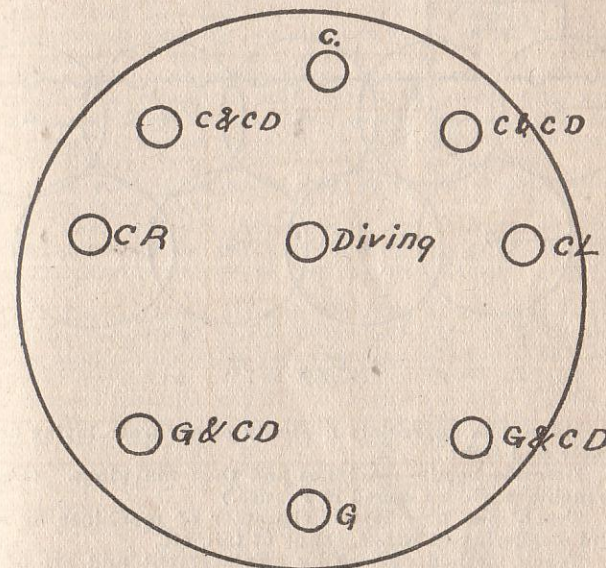


Fig. 30.

NOTES.

1. Sights not interchangeable. (Various types of guns.)
2. Be sure casing is full of water.
3. Fire long bursts—interval—long bursts.
4. Don't allow for wind unless blowing a gale.
5. If no special sight available, aim two fingers in front of plane.
6. Tracer amm. smoke.
7. More tension needed on recoil spring.
8. Markings in hostile and friendly planes must be shown.
 1. English—Concentric circles—Blue, White and Red.
 2. French—Concentric circles—Red, White and Blue.
 3. Belgium—Concentric circles—Black, Yellow and Red.
 4. German—Black Maltese Cross—plainly visible at shooting distance.
9. Gun must be kept horizontal normally.
10. No loose pockets in belt, ammunition falls out.
11. Gun squad must be ready instantly on call of sentry.
12. Mountings—various special mountings, can use mark iv. tripod by turning cross head a round 180° trail in front.
13. Anti-aircraft defense of a system.

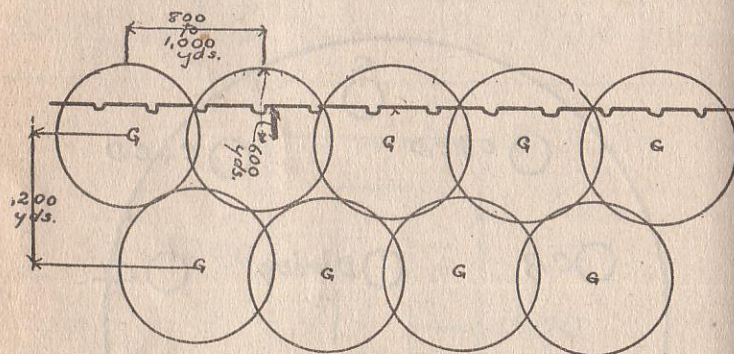


Fig. 31.

14. Make men appreciate necessity of accurate laying according to table and sight.
15. Describe hostile machines and then markings. (Description of machines will be issued in France.)
16. Teach men how to tell character of machines by shape, curve and staggering of wings, shape of tail, etc.
17. Teach method of making emplacement and art of camouflage.
18. Use of tracer amm.
19. Look up subject of armor piercing amm.
20. Have general instructions for anti-aircraft work, and draw an enemy machine like a plane and teach laying in it. (Rig on wires.)
21. If near aviators' school, ask them to demonstrate machine flying at 1,000, 2,000, 3,000, 4,000, 5,000 feet.

THE EMPLOYMENT OF MACHINE GUNS.

INTRODUCTION.

1. The experience gained since the commencement of the battle of the Somme on July 1, 1916, the ever-increasing mass of Artillery employed on both sides, the development of the machine-gun corps, the larger number of machine guns available, the increased supply of Lewis guns to Infantry battalions, the advance made in the study of scientific machine gunnery, and changes in tactical methods on the part of the enemy, have rendered necessary a revision of former instruments on the subject of the employment of machine guns.

The present publication is intended to set forth the principles which would guide commanders both in the tactical employment of machine guns and in the organization and direction of their fire.

2. Next to the Artillery, the machine gun is the most effective weapon employed in modern war, and against troops in the open at suitable ranges it is proportionately even more effective than Artillery, for the fire of one machine gun is more annihilating than the effect of one gun or Howitzer.

It is therefore essential to success in war that the problems of machine gunnery should be appreciated and studied not only by machine gunners, but also by all those who have in their hands the organization and direction of machine-gun work.

3. Machine gunnery is a study in itself, as difficult and scientific as that of field gunnery; and if the full value is to be obtained from the machine guns available, the personnel of the machine-gun corps must reach the high degree of professional knowledge that is possessed by the personnel of the Artillery. Every opportunity therefore should be taken of attaching machine gun officers to Field Artillery batteries for periods of instruction.

4. The study of machine guns and their employment may be divided into three parts:

(a) The technical properties of the machine gun, including the mechanism of the gun and the methods of giving instruction on it. This part is covered by Part I. (Mechanical), of this publication.

(b) The organization and direction of machine-gun fire, including the theoretical considerations affecting the fire power of the machine gun, a thorough understanding of maps and the instruments and appliances used in machine gunnery, and the practical application of machine-gun fire to meet all tactical requirements.

(c) The tactical employment of machine guns.

This is dealt with in this part of this publication. But it is impossible for the student to handle practically the problems of machine-gun tactics, if he does not possess sufficient technical knowledge to appreciate the powers and limitations of the weapon, the basis on which the fire of one or more guns is directed, and the conditions under which in any particular situation the fullest fire effect will be obtained; and therefore PARTS I. and II. must be studied in conjunction.

5. The distinguishing feature of modern machine gunnery is its offensive power. The offensive intention has always been present, but lack of training and technical equipment hindered its realization and led to the impression that the machine gun, while a powerful weapon in the defense of ground gained, could do little to assist the Infantry in its capture.

Modern machine gunnery has reversed this passive tendency, and recent experience proves that the methods of offense now employed by machine gunners are viewed with confidence by the Infantry for whose support they have been designed. Therefore, in future the machine gun must be regarded not merely as a defensive weapon, but as a weapon capable of supporting the Infantry during an attack and protecting them against counter-attack during and after consolidation. In every operation machine guns must be organized, and their fire directed, with a view to developing to the full their offensive power; and in all training the offensive spirit in machine gunnery must be inculcated.

NOTE: By "machine gun" will be understood throughout the present publication the "heavy type machine gun."

CHAPTER I.

PART I.—TACTICAL EMPLOYMENT.

GENERAL CONSIDERATIONS.

1. The Roll of Machine Guns.

1. The tasks which machine guns will be called upon to perform may be summarized as follows:

(a) In warfare of highly organized defenses:

Creeping or standing barrages, frontal or enfilade, in co-operation with the Artillery during the Infantry advance, and direct fire and defensive barrages when the Infantry have gained their objectives.

Neutralizing fire, i. e., intense searching fire on areas from which long range rifle and machine-gun fire can be brought to bear against our Infantry.

Harassing fire.

Barrage fire to cover raids.

Direct fire and defensive barrages for the repulse of attacks initiated by the enemy.

(b) In warfare of improvised defenses and in open fighting:

Offensive and defensive tasks of the same nature, including tasks that have hitherto been allotted almost entirely to the Field Artillery, but for which there may not be sufficient Artillery available.

Against an enemy in shell hole defenses, or in the open, searching fire will be effective at extreme ranges (2,500 to 3,000 yards).

2. Accurate indirect fire is necessary in most of the above work, and therefore machine-gun officers must be trained to organize machine guns for collective action in support of the Infantry both by indirect fire and by direct fire whenever this is possible.

3. When employed on the defensive, the machine gun is a great economizer of Infantry, for owing to its fire power it enables a defended line or area to be held by a minimum of Infantry, thereby enabling the mass of the Infantry to be kept further back, ready for counter-attack or a subsequent offensive.

In particular the fire power of the machine gun enables—

(a) The ground gained in an offensive to be held by the minimum of Infantry, thereby reducing the casualties from subsequent bombardment;

(b) A minimum of Infantry, compatible with keeping the trench system in repair to be kept in the line in ordinary trench warfare, thereby lessening the daily wastage from casualties and trench sickness and the loss of efficiency through long periods of trench life;

(c) The enemy to be held on one portion of the battle front with the minimum of Infantry and Artillery while the maximum of Infantry and Artillery are concentrated for offensive action on another portion of the front, where decisive action is intended.

4. All the foregoing call for liaison between the machine-gun corps and other arms, especially the Field Artillery. It is only by co-operation between the Field Artillery and the machine-gun corps, that machine guns can assist effectively in making good any shortage of field guns.

CHAPTER II.

WARFARE OF HIGHLY ORGANIZED DEFENSES.

THE OFFENSIVE.

2. Principles of the Attack.

The Nature of a Modern Trench Attack.

It is necessary that machine-gun officers should study carefully the nature and formation of Infantry attacks in a war of highly organized defenses, in order to appreciate the work of machine guns in assisting that attack as laid down in the following sections. The attacking troops advance at the rate of about a hundred yards in three minutes with their rifles at the high port. Opportunities for fire during an advance are rare, fighting takes place on reaching the objective. The artillery creeping barrage acts as a covering fire, the attackers must keep close up behind it (100 yards is the normal), as this creeper is gradually moving up on to the objective the enemy is forced to keep his head down and take cover. When the creeping barrage has reached the objective, the advancing troops are about 100 yards short of it; and then it lifts 100 yards beyond the objective. The infantry rush in, bayonet the survivors in the enemy trenches and bomb the remainder in their dugouts. The further the advance into the enemy's defenses the more stubborn is the assistance. Lines of trenches and posts are not taken as a whole but have to be fought for by close fighting, working along the line laterally and making use of the various weapons at the disposal of our Infantry. This is the work of the moppers up. The enemy immediately retaliates by making small local counter attacks or by inflation. As soon as he finds this method a failure and our troops have consolidated he organizes a set piece counter attack. This counter attack is usually preceded by an intense artillery bombardment directed upon the ground we have won, and the enemy then attacks in large forces, usually in mass, hoping to thus recapture the whole lost system of defenses. The enemy counter attack will be directed against the strong posts of his old lost system, for it will be these we shall have garrisoned during our consolidation. The machine guns must therefore be placed to screen such parts and successfully arrest the enemy by annihilating bands of fire in depth throughout the captured enemy defenses.

1. The machine guns available for any operation are most effectively employed when they are organized as a whole in accordance with a general scheme, and allotted to formations in accordance with the tactical requirements of the situation.

Machine-gun resources must be kept fluid, work of every gun considered and a definite role allotted to it.

2. There must be co-ordination of the machine-gun work throughout the whole force taking part in any operation. In a big operation the machine-gun work will form part of the corps plan, and will be co-ordinated with that of the corps on the flanks.

3. Direct fire over the sights at the target is the most effective form of machine-gun fire. But although frequent opportunities should be forthcoming for employing with effect the direct fire of machine guns in open fighting in the attack as well as in the defense, yet the opportunities for using this form of fire to support Infantry in the attack of highly organized defenses are rare.

4. The offensive power of the machine gun has been increased by the progress made in the tactical employment of large numbers of machine guns for indirect fire. The experience of recent fighting proves that in attacks on organized defenses alike, machine guns have rendered most assistance to the Infantry when they have been handled collectively and used in the main to give indirect fire, and that to resist counter-attacks the fullest value from machine guns is obtained by a combination of direct and indirect fire, part of the guns being retained in the rear to put down an overhead barrage on an S. O. S. line, and part being sent forward to support closely the attacking Infantry.

5. The role of machine guns will be understood by other arms in the light of the foregoing. In particular it must be remembered that while the machine guns always fight for the Infantry, they do not necessarily fight with them.

3. Classes of Guns.

The machine guns available for an operation will be divided into two classes:

(a) Mobile guns, i. e., the guns allotted to Infantry brigades to go forward in support of the attacking Infantry, and carry out consolidation in depth of the ground won.

(b) Barrage guns.

In addition there should be some guns in reserve.

(c) Guns remaining in our front line system.

4. Roll of Mobile Guns.

1. The role of every gun will be laid down in orders, i. e., the location at zero, the routes of advance, the final locality from which it is employed, the nature of that employment, and the Report Centers through which orders will reach the commanders of mobile guns.

2. Apart from exceptional circumstances, such as when they form part of a detached force, these guns should not be definitely attached to Infantry battalions.

The machine gun is not a suitable weapon to send forward tied to an Infantry formation for the following reasons:

(a) Its weight, which makes it practically impossible for the machine gunner to keep up with the Infantry. Even if he succeeds in doing so, he becomes too exhausted to be useful until some time has elapsed.

(b) Its visibility, as compared with the Lewis gun, which makes it difficult at short notice to find a concealed position from which to use it, and leads to its being quickly knocked out.

(c) Now that each Infantry battalion has a large number of Lewis guns, the necessity for attaching machine guns to it has ceased to exist. The Lewis guns and other Infantry weapons are usually sufficient for repelling infiltration and early local counter-

NOTE: Where Lewis guns are mentioned it will be understood as referring to automatic rifles in general.

attacks. Machine guns should aim at getting into their consolidation positions in time for the set piece counter-attacks which come later.

3. Too many machine guns should not be pushed forward into the advanced portions of the captured position for early consolidation as this only results in useless loss of personnel and material, and in reducing the number of machine guns available for the S. O. S. barrage by which the Infantry are protected during consolidation.

The number of mobile guns per brigade will depend on the tactical situation, and the task the Infantry brigade has to perform. It will usually be from four to six. A rough guide is one machine gun per 100 to 150 yards of front to be consolidated.

4. The guns will usually work in sub-sections of two guns, each sub-section being under an officer.

5. The location of the guns at zero will be chosen with regard to the line on which the hostile barrage will most probably first descend. They should, as a rule, do no firing before their advance. Thus they will be packed up, and their personnel fresh when the time to move forward arrives. An exception to this would be guns taking part in a barrage during the earlier phases of an attack, and being picked up by troops passing through to take part in a later phase of the operations.

6. In order that they may not become mixed in the melee, they will not follow the attacking waves too closely. The advance will be by bounds, along previously selected routes. The halting place at the end of each bound will be given in advance, and should not be in proximity to any prominent landmark.

7. The localities from which the guns are to be employed finally will also be laid down, and representatives of the mobile guns, preceded by their scouts, to reconnoiter these localities and choose the actual position of each gun.

8. There are two ways of conducting this reconnaissance:

(a) Each bound being reconnoitered separately.

(b) Representatives going forward with the Infantry to the final localities, and sending back for the guns when they are required.

9. It is usually best to cross No Man's Land early, so as to avoid the enemy barrage, and to make the enemy front or support lines the first halt. The guns will not leave the last halt to move forward to their final localities until the final position for each gun has been selected. They will then be guided direct to the positions from which they will come into action.

10. Open emplacements should, when possible, be prepared for them, before they are brought up.

11. The guns both in their intermediate and final locations will be distributed in depth.

12. Each sub-section of mobile guns will be allotted a Report Center, which normally will be the headquarters of the battalion in whose rear they are operating. The commander of the sub-section will have runners at his Report Center, so that messages can reach him if he is not there himself at the time. In this way the ordinary channel of communication between brigade headquarters and advanced battalion headquarters can be used for communication with the mobile guns. The sub-section commander will report to the battalion commander in whose area he is operating, when his guns have taken up their allotted positions.

5. Roll of Barrage Guns.

1. The object of barrage fire by machine guns is two-fold, to assist the Infantry during the advance and to protect them during consolidation.

During an advance machine-gun fire will be inadequate unless it is applied continuously and along the whole front under attack. In the storm of a battle it is impossible to engage in detail the enemy targets ahead of the advancing line, and therefore it is necessary to sweep systematically all ground which may contain these targets. The enemy relies upon his machine guns to hold us up once our attack has been launched, and these guns are usually sited in the open between the various objectives to be taken. They are designed to fire through our Artillery creeping barrage before it reaches them, and on to our advancing Infantry. It is the machine gun creeping or "sweeping" barrage moving ahead of the Artillery barrage, which is intended to muzzle any such resistance of fire power. Similarly after a successful advance when the assaulting troops are in unfamiliar surroundings, ignorant of the exact disposition of their resources, and exhausted by the physical and nervous strain of their recent effort, and when the work of consolidation is not sufficiently advanced to be of great value in repelling an attack, the Infantry's power of resistance must be strengthened by fire from the rear, which is applied the moment it is called for, and on as wide a front as the counter-attack demands. (S. O. S.)

2. The Infantry advance will be covered by:

(a) Standing barrages, placed on or beyond the various lines to be attacked, and remaining there until such time as the Infantry advance renders it necessary for them to be placed further forward, or

(b) Creeping barrages, moving in front of the 18 pr. creeping barrage and intensifying its effect; the machine-gun lifts being not less than 100 yards. This is the more thorough method, and when time and resources permit, will be the most effective. The covering barrage will, when necessary, be supplemented by:

(a) Standing barrages, placed on enemy lines of communication likely approaches for enemy, counter-attacks, open ground over which the enemy must retire or be reinforced.

(b) Neutralizing fire, on commanding ground or other areas from which observation can be obtained and fire directed on our Infantry.

(c) Neutralizing fire, on positions which, though not being directly attacked at the time, are being enveloped or are holding up an attack already in progress.

3. During consolidation the Infantry will be protected by S. O. S. barrages, arranged to go down as close in front of the line which is being consolidated as is consistent with the safety of the troops occupying it.

4. The direction from which barrage fire can be applied is either frontal, oblique, or enfilade, but as oblique fire is a form of enfilade fire, it is only necessary to compare frontal with enfilade barrages.

Frontal Barrages.

Advantages: It is usually the only one possible to employ on a general scale for covering the Infantry in a big operation; it gives a greater depth of beaten zone, i. e., the attackers walk up the cone instead of across it; it is simple to arrange and carry out.

Disadvantages: It requires more guns to cover a given front; it cannot be placed so close to the Infantry.

Enfilade Barrage.

Advantages: It can be placed somewhat closer to the Infantry; it requires less guns to cover a given front; it is more effective against trenches and streets which run at right angles to the general line of advance; it is especially suitable for the protection of an exposed flank.

Disadvantages: It is seldom possible except in small operations, or in operations where one portion of the line is in advance of that from which the attack is being made; it gives a narrower beaten zone; it is more difficult to arrange and carry out.

It can therefore be concluded that frontal barrages will be the normal type of barrage for covering the advance of the Infantry and forming the S. O. S. barrage line; but that, when sufficient guns are available and the conformation of the line permits, a combination of frontal and enfilade barrages will be the surest means of obtaining the fullest effect from the fire of machine guns.

5. When the ground is exceptionally favorable or has build-ups on it, it is sometimes possible to use direct fire for covering the advance of troops. As a rule, however, if much Artillery is being employed, the dust renders observation impossible. Attacks frequently take place in the half light of early dawn at an hour when owing to darkness or morning mist it is not possible to see over the sights, and the control of a large number of guns by any means, except that of the time table, is out of the question.

6. The barrage guns, especially those forming the S. O. S. barrage line, form a strong rear line of defense in the event of the enemy breaking through, and at the same time a protection to our own Artillery and a reserve of power available to meet any new situation that may raise.

4. Organization of Barrage Guns.

1. In a big operation the general scheme will be drawn up by the corps, in order that all the available machine guns may be used in the most effective manner and that the necessary co-operation with neighboring divisions and corps may be assured. The same care must be taken to co-ordinate the machine-gun barrages on neighboring fronts as is taken with the Artillery barrages. The creeping barrage of the machine guns should be simple and complicated lifts and changes of direction avoided.

2. The general scheme having been drawn up and the divisional machine-gun officers conferred with, they, in their turn, will organize the guns at their disposal in accordance with that scheme.

3. At the divisional conference the divisional commander, in consultation with the brigadiers and the divisional machine-gun officer, will have decided on the number of guns to be allotted to each category, and on the proportion of guns and personnel to be kept in reserve to replace casualties and to carry out reliefs.

4. The barrage guns will be divided into "Groups," usually one group to each brigade front. This will facilitate communication, and ensure the commander of a group of batteries being in close touch with the commander of the brigade which he is supporting. Each group will be sub-divided into "Batteries." If the number of batteries in any one group exceeds four, it may be convenient for the sake of control to form sub-groups. The normal number of guns in a battery is eight; it may be less, i. e., four or six, but owing to difficulties of control, should not be more.

5. Each group will be under the command of an officer ap-

pointed as "Group Commander." It is essential that he should have his headquarters at the headquarters of the brigade whose area his group is covering.

He will be in telephonic communication with his batteries.

6. Each battery will be under the command of an officer appointed as "Battery Commander."

7. In each battery there should be at least one officer to four guns, and one N. C. O. not below the rank of corporal, to two guns. The battery commander is responsible that proper control is exercised throughout his battery.

8. The divisional machine-gun officer should be at divisional headquarters, in close touch with the General Staff of the division. He will be in communication with his group commanders and also with the officer on corps staff who is dealing with machine guns.

7. Harassing Fire.

1. The object of harassing fire is to prevent overland movement by the enemy and to dislocate the supply and maintenance of his front system. The fire will usually be at night. An organized scheme for carrying it out will be put in operation a certain number of days before an attack and maintained in intensity until zero day.

2. The original scheme and the daily program will be worked out by the divisional machine-gun officer, in co-operation with the general staff of the division and the divisional Artillery staff, and will be co-ordinated by the corps. In order to secure a proper division of work the machine-gun scheme of harassing fire should be part of a general scheme embracing the operation of artillery, machine guns and trench mortars. Co-operation with the Intelligence (GSO.3) will ensure that the harassing scheme is kept up to date as regards "points sensibles" in the enemy's lines.

3. Key maps should be issued to machine-gun officers in charge of guns engaged in harassing fire. This reduces greatly the delay in getting out the daily fire program.

4. For details of targets and types of fire see Part IV.

5. For Liaison and Harassing schemes see Part III., Section 4.

8. Siting of Barrage Guns.

1. Batteries must be carefully sited in positions behind hedges and other inconspicuous places. When these are in view of the enemy, the emplacements must be dug by night and kept camouflaged during the day. If the terrain is very exposed it may be inadvisable to dig any emplacements before zero night, the ground being merely pegged out in advance. (See Sec. No. 32, also Appendix V., "Notes on Field Fortifications.")

2. Care must be taken to avoid movement near the battery positions by day, and the making of beaten tracks leading up to them, as they are very visible on aeroplane photographs.

3. Once the battle has begun, it is often no longer possible, except under very favorable conditions, to conceal the battery positions, and the success of the battle must be relied on to prevent the enemy being able to divert sufficient Artillery from his original program to deal effectively with the barrage guns.

4. Precautions should be taken against low flying aeroplanes. Lewis guns posted away from the battery positions but within range of such aircraft, would prove valuable for protecting the guns during the battle.

9. Forward Movement of Batteries.

1. The arrangements for the forward movement of a large number of batteries, with the necessary ammunition, spare parts, water, oil, etc., are complicated and divisional machine-gun officers

are responsible for preparing the detailed instructions for the forward moves of the batteries forming the groups under their command.

2. Time of starting, route, halting places, final location, time of arrival, will be given to each battery, and maps prepared showing all details.

In addition, the calculations necessary to enable the batteries to open fire from their new positions in the shortest possible time will be worked out beforehand, and the necessary fire orders and fire organization tables issued. Oblique aeroplane photographs should be supplied to all batteries moving forward.

3. Wherever possible pack animals should be used to assist the batteries in their forward move. It may sometimes be advisable to place the pack animals, while they are waiting for the time to advance, in pits which have been dug in rear of the battery, but not so close as to disclose its position.

4. Whether pack animals are used or not, batteries require assistance from the Infantry on the scale of two extra carriers per gun. These must be picked men, selected for their physical strength and staying power, and they should be attached to the machine-gun companies for some time beforehand in order that they may be trained in their duties. The importance of the work of carriers cannot be exaggerated for in most cases ammunition has to be man-handled up to the guns, and the demand for filled belts is continuous throughout offensive actions. That they are as indispensable to the gun as the No. 1 himself must be impressed on these Infantry carrying parties, who should also be imbued with the right machine-gun esprit-de-corp. With training they become a nucleus of reserve gunners, capable of, themselves carrying on at the guns in case of heavy casualties.

5. All forward moves should be rehearsed beforehand over ground which resembles as nearly as possible that actually to be crossed.

During these practices and at other times the personnel will be trained in the carrying of their loads for long distances, and everything possible will be done to increase their fitness for the task that they will have to perform.

10. Final S. O. S. Barrage.

1. This will be arranged so as to provide a complete screen of fire along the whole front of the operation.

If the operation is one in which the length of the advance makes it necessary for the Artillery to move forward, it is all the more essential to prove this curtain of machine-gun fire as early as possible after the Infantry have reached their final objective.

2. All necessary arrangements and calculations will be made beforehand, as per Sec. 10, Par. 2.

3. These arrangements will contemplate the possibility of the Infantry making good their final objective on one part of the front, and failing on another. In order that the successful troops may not be compelled to withdraw, the protective barrage will have to be maintained ahead of them, and at the same time drawn in to cover their exposed flank and the front of the troops who have advanced less far.

This is only possible if, and when, the position of friendly troops is exactly known.

11. Unity of Method in Attack and Defense.

The method by which barrage fire is carried out is given in detail in Part II, and it is the same both for the attack and the

defense, the only difference being that under defensive conditions the arrangements will on the whole be simpler. This unity of method is in accord with the fundamental unity between the offensive and defensive roles of the machine gun. For the attack, as already, shown implies the covering of an assault and the repulse of counter-attacks, and the defense, as will be shown in the sections which follow, develops an active nature in proportion as it is organized on scientific lines.

PRACTICAL AND ADMINISTRATIVE CONSIDERATIONS FOR MOBILE GUNS.

(1) Arrangements Within Our Own Lines:

a. Company headquarters and advance report centers. Company headquarters before an attack will be around regimental headquarters somewhere in the intermediate line. Arrangements must be made for complete communication immediately after an attack through the advance report centers so that the platoon commanders are able to communicate with the captain, and he with them. The regiment will also have an advance report center established at this time. If the attack is a success, both advance report centers will later be transformed into respective headquarters; so they should be located in close proximity. Up to these places should go the second in command along with an extra officer and the company signalers. They should move up as soon as the attack starts.

b. Dumps and advance dumps: Before the attack the dump should be well up in the front line if possible, or at least in the support line. That dump will include such things as: ammunition, 200 boxes of 1000 rounds each, spare rations and water, sandbags, picks and shovels, spare parts, etc. The advance dump site is generally chosen by personal reconnaissance and is known to all ranks. It will be somewhere near the site of the advance report center. Immediately that the attack is under way carrying parties arranged by company headquarters go forward with their loads from the company dump to the advance dump. The idea is that the whole organization is pushed forward.

(2) Communications:

This phase of the work is simple under the advantage of the existing Bn. lines. The regiment keeps open a line from regimental headquarters to the regimental advance report center, and to the attacking Bn. report centers. The Machine Gun Platoon Commander makes reports through the Bn. lines to the regimental advance center, where the second in command of the M. G. Company gets the message and sends it on to the captain, who is at regimental headquarters and he is in touch through the brigade headquarters with the barrage guns, so there is complete communication and hence co-operation.

(3) Who is to be left out?

Twenty-five per cent or one-fourth of the company must stay out of the attack as a mobile reserve to replace the worn out and the casualties, because it is too far to the bases to get men up before they might be needed. The mistake of leaving the poor men behind and using good men should not be made.

(4) Explain everything in detail to subordinates:

Nothing is too detailed to be explained to your officers and they, and if possible the sergeants, should accompany you on all personal reconnaissance before an attack.

(5) Prepare Operation Orders.

(a) They should outline the job of each platoon.

(b) You should require the platoon officers to read them in your presence.

(6) Load to be Carried by Gun Team in the Attack.

There will be one N. C. O. and seven men. Five of the men will each carry two belt boxes, that will be 2500 rounds. Besides this the whole team will carry two bandoliers of 60 rounds apiece, making a total of 960 rounds for the eight men. Thus we have nearly 3500 rounds of ammunition right along with the team and gun. The ammunition is all in belts, the bandoliers having been adjusted to hold short belts of 60 rounds. The belt filling machine can therefore be left at the dump (advance dump). No. 1 carries the tripod, No. 2 the gun, cleaning rod and spare parts wallet. No. 1 also carries a very pistol in his belt.

Every man carries two days' rations, two grenades, two very lights, two sand bags and his regular equipment. The only water carried is what is in the canteens and the gun reservoir.

(7) Synchronization of Watches.

Done by an officer in person, using two reliable watches with second hands upon them. It usually states in field orders when this will be done. Should always be done methodically and in person, never over a phone, if you can help it.

(8) Carrying Parties. (See Sec. 10, Para. 4.)

(9) Rehearsals.

More is learned through well organized rehearsals than at any other time except in an actual attack. It gives all ranks a lot of actual practice and can be made very similar to the real thing.

CHAPTER III.

WARFARE OF HIGHLY ORGANIZED DEFENSES—THE DEFENSIVE.

1. Principles of Defense.

1. The scheme of defense in normal trench warfare consists of an area defended in depth by one or more defensive systems.

2. The front system is composed usually of an elaborate network of trenches and strong points, arranged roughly in three lines as follows:

(a) A first line, which is in the nature of an observation or outpost line, and which as a general rule comprises a series of posts held by small numbers of infantry with the help of Lewis guns, these posts being connected by trenches.

(b) A second or support line, which consists of a continuous line held in strength by the infantry.

(c) A third line, generally the main line of resistance, which consists of a connected series of strong points designed to:

(i) Break up an enemy attack by denying to him the most important features.

(ii) Form rallying points behind which troops driven from the front two lines can be reformed.

(iii) Split up an enemy attack in such a way that hostile elements which break through between the points shall be exposed to destruction in detail.

(iv) Allow of counter-attacks issuing between them for the

purpose of ejecting from the two first lines an enemy who has succeeded in establishing himself in them.

3. Behind this front system will be other defended lines, or systems, consisting of woods and villages prepared for defense, and of trenches and redoubts commanding features of tactical importance.

4. The methods of employing machine guns for assisting in the defense of the front system will alone be considered in the present publication. All the principles of machine-gun defense are contained therein, and the extent to which the rear systems can at any time be manned depends on the guns and personnel available.

5. It is a great principle of war that as few men as possible shall be employed in a purely defensive role, while as many as possible are kept ready for offensive action.

This principle is observed when the fire power of machine guns is so employed that the trench system is held by a minimum of infantry, and consequently with a minimum wastage of man power. (See Section 1, Paragraph 3).

6. The fullest service, however, cannot be rendered to the infantry unless the liaison between the artillery and machine guns is close. This point has already been noticed in Section 1, Paragraph 5, and elaborated in Section 8 in connection with harassing fire previous to an attack. In defense it is of no less importance. The defense provided by the artillery, machine guns, and trench mortars must constitute a combined scheme in which each arm supplements the others. In places where, and on occasions when, the shortage of field guns precludes a complete defensive barrage of artillery fire, co-ordination is all the more important.

7. In the case of any enemy attack the role of the machine gun is:

(a) To disorganize the attack in its origin, by firing on the area from which it is launched.

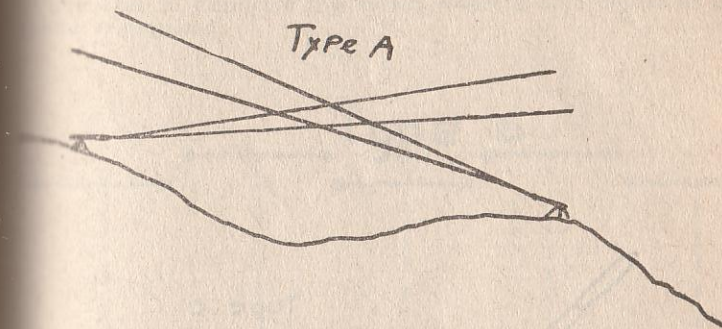
(b) Should the enemy penetrate into the defended area, to arrest him by annihilating fire at short ranges, and hold him up at all costs until time has been given for the organization of the lines or systems in rear, and the preparation and launching of a counter-attack.

8. This role necessitates arrangements, whereby effective screens of machine-gun fire can be placed in the path of an advancing enemy.

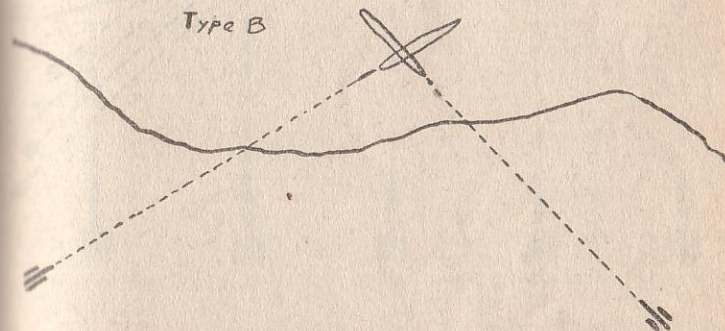
The aim is not to site machine guns so that every yard of ground is swept by machine-gun fire, but so to combine the machine-gun defense with that of the Lewis guns of the infantry that machine guns will play the part that is dictated by the characteristics of the weapon, and will not be wasted in doing work that can be performed by Lewis guns, such as firing on small depressions or down trenches. Machine-gun fire should be reserved for protection on a bigger scale, screening the more important features and denying to the enemy the most favorable routes of advance. Points of tactical importance must be strongly screened even though, owing to a shortage of guns, it is necessary to leave gaps on parts of the front where an enemy attack is probable.

Types of Machine-Gun Fire.

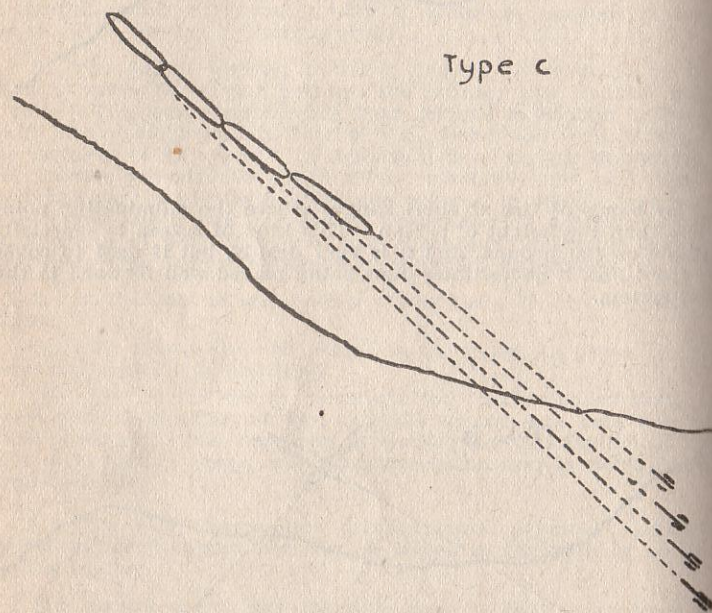
Screens of machine-gun fire are of different types according to the way they are produced:



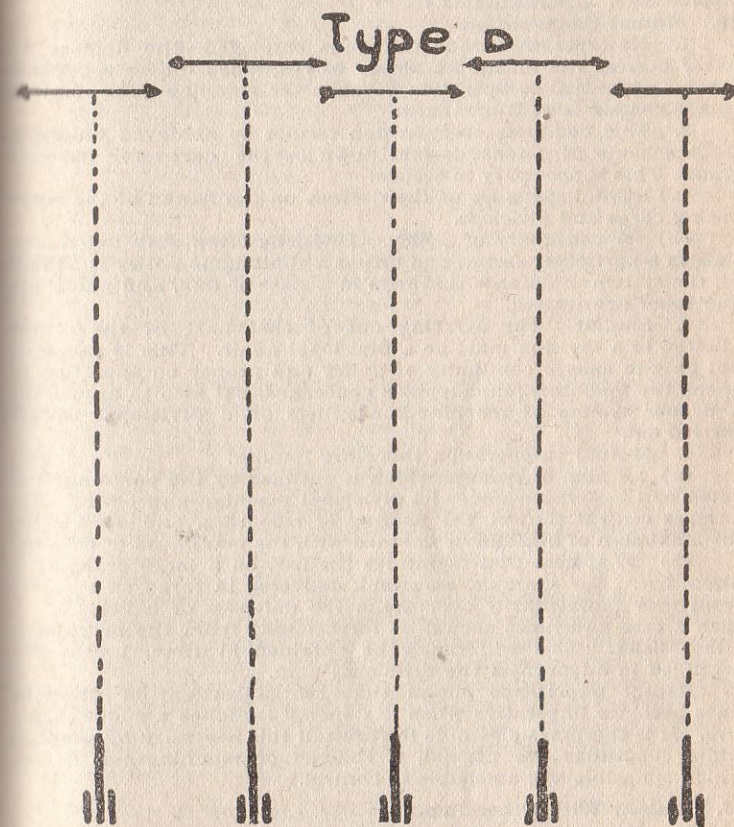
By bands of fire at short ranges where the culminating point is less than the height of a man. This kind of screen is especially suitable on flat ground, and it is very deadly, but if used to cover the front line, it necessitates guns being placed well forward in the front system.



By oblique locking of beaten zones at moderate ranges. This type covers less ground per gun, but it allows of guns being placed further back. The extent of the zone varies with the slope of the ground swept, being greater on ground falling with respect to the line of sight.



By locking in depth, that is to say, an enfilade barrage. This is a practical application of combined sights. It is most suited for the protection of a salient or exposed flank, and it may be possible to apply it to a re-entrant when the guns themselves can be brought into a salient and fired almost parallel to the front. The width of the beaten zone of a machine gun being narrow, it may be advisable to duplicate this screen where a high degree of protection is required.



By frontal fire in which the front covered by each gun depends on the number of guns available, but should not be more than 50 yards. The efficacy of this type of screen depends on:

- (i) The number of guns available and their rate of fire.
- (iii) The time taken by hostile troops in passing through the screen.

This is the normal type of S. O. S. protective screen fired over the heads of the infantry.

(15.) Direct Laying and Indirect Fire.

In comparing the scope for direct and indirect fire, it should be borne in mind that it is often possible to lay the guns by direct observation and subsequently necessary to fire them indirect, either because the enemy's attack comes at night or at early dawn, or because visibility is obscured by the smoke and dust of the enemy's bombardment and by his smoke screens. Guns laid to fire direct should always be equipped for firing indirect, should the need arise. (See Section 5, Paragraph 6.)

16. Mutual Co-operation.

1. However numerous the guns employed, the defense will never possess the maximum power of resistance unless a complete scheme of mutual co-operation between the machine guns employed in a defended area is arranged.

2. This complete co-operation cannot be achieved unless the main scheme of defense is laid down by the corps for its whole front. This is necessary to secure:

(a) The linking up of the defense on the flanks of the neighboring corps and divisions.

(b) A continuity of policy. Divisions often stay but a short time in a particular sector, and unless a continuous policy is adhered to, the system of defense is always in a state of flux, and much time and labor are wasted.

3. Similarly the carrying out of that part of the scheme allotted to a division must be a divisional affair. This is necessary, not only to ensure continuity of policy and proper co-operation between the machine-gun companies concerned, but also to ensure that a proper system of machine-gun reliefs on a divisional basis is carried out.

4. Mutual co-operation therefore implies:

(a) A plan of defense which is outlined by the corps and executed by the division under its divisional machine-gun officer. This ensures central control, the pooling of resources, and, as a result, the maximum of flexibility combined with the maximum of economy.

(b) A system that facilitates the use, on a large scale, of indirect fire. For example, an attack delivered in force on a narrow front may momentarily overwhelm the defenses of a brigade. In such a case assistance should be forthcoming from the brigades on either flank. This will rarely be obtained in time, unless it is arranged in advance in the divisional plan.

Recent experience shows that reorganization on divisional lines becomes imperative when the enemy launches a sudden offensive. It is therefore desirable to forestall this necessity by adopting, while conditions are normal, a scheme of machine-gun defense which is flexible and amenable to control.

17. Liaison With Other Arms.

(For detailed practical workings see Part III, Section 4.)

1. Co-operation among the machine guns must be accompanied by the closest co-operation with the Infantry brigade and with other arms.

2. There must be continuous collaboration with officers commanding Infantry formations, in order to secure that the scheme of machine-gun defense shall be in harmony with the distribution of the troops whom it is desired to protect, and that machine guns and Lewis guns shall not overlap or try to do each others' work. Cases

will arise where a machine gun can do rather more reliably the work which belongs to a Lewis gun, but only at the expense of neglecting work which is essential to the general scheme of defense, and which the machine gun alone can do. The officer commanding the machine-gun company operating with the brigade must see that the general divisional plan is accommodated with the brigade must see that the general divisional plan is accommodated in detail to the dispositions of the brigade.

3. Liaison with the Artillery is required in order:

(a) To work out a S. O. S. line of combined Artillery and machine-gun fire in the proper proportion and of the desired depth.

(b) To co-operate in schemes of harassing fire at all times, and not merely on the eve of a big attack.

(c) To obtain information about the enemy, which the Artillery with its more elaborate system of observation has at its disposal.

(d) Use of Artillery O. P.s and instruments.

4. Liaison with the Engineers and pioneer companies is required in order:

(a) That new wire may be sited, representatives of the machine guns, engineers, and Infantry act in concert. Machine-gun positions and wire should be sited simultaneously.

(b) That emplacements may be of the type required under the latest conditions. Similarly with regard to camouflage and tunneling.

18. Method of holding Front System. See Sec. 13, Paragraph 2.)

A sector of trenches should not be regarded as a mere series of successive defense lines to be held one after another, but, as a single defended area, the protection of which is laid out upon a definite plan; according to the nature of the ground.

The first question to consider in drawing up a machine-gun defense scheme for any sector of trench is the main line of resistance, that is, the line beyond which the enemy's attack must not penetrate. A decision on this point will decide the correct allotment of guns in depth.

It is possible for an intensive Artillery bombardment to destroy the front and support lines, including any machine guns that may be in them, unless they are accommodated in deep dugouts. If guns are kept in deep dugouts in front trenches, their chances of coming into action are small, since by the time they are mounted the enemy will be on top of them. Machine guns, therefore, must usually be placed in rear of the support line. The responsibility of holding the front line rests with the Infantry and Lewis guns, assisted from the rear by machine guns.

19. Number of Guns in Front System.

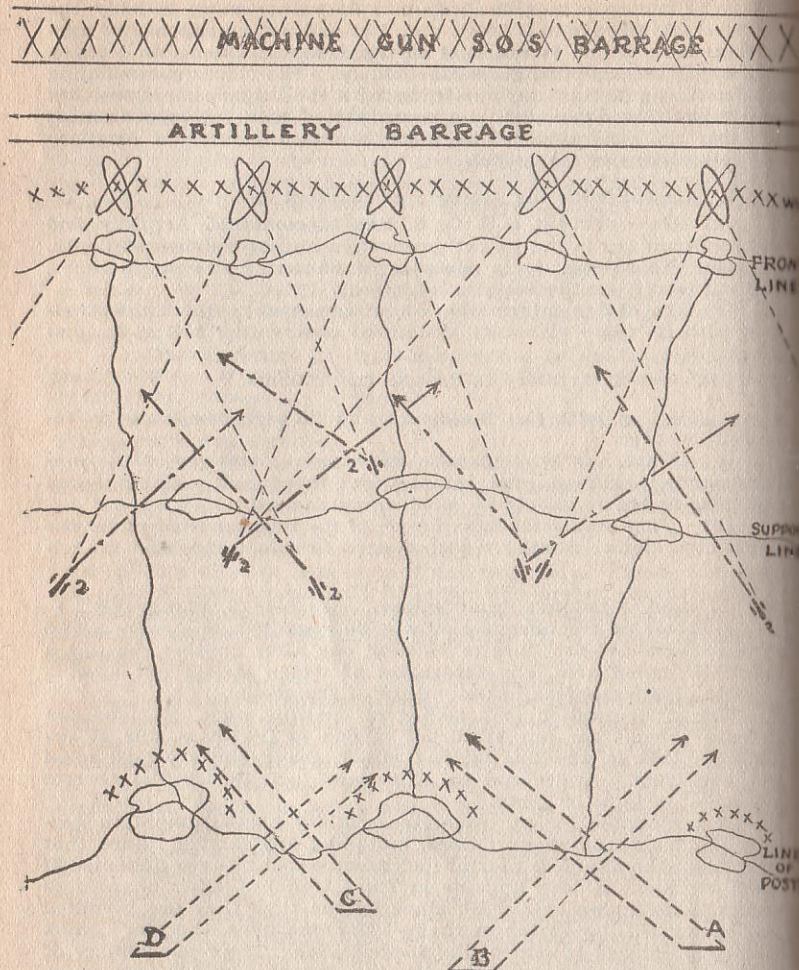
The number of guns employed in the front system, will be determined by:

(a) The total number of guns available.

(b) The nature of the ground, and the tactical situation.

(c) The amount of cover that can be provided, and the time that it will take to bring the guns into action.

(d) The arrangements for the relief of gun teams. These latter must be adequate, and are specially important when heavy shelling, bad accommodation, and severe weather have to be faced.



KEY.

- == FORWARD GUNS, with double lines of fire.
- D BARRAGE BATTERIES, showing direction of fire in case of penetration of support line.
-

20. Classes of Guns.

In conformity with the principles of defense in depth, provision must be made for a combination of direct and indirect fire; and, as before, the machine guns will fall naturally into two categories:

(a) The forward guns corresponding to the mobile guns. (See Section 4.)

(b) The barrage guns.

21. The Forward Guns.

1. These guns should be arranged in pairs, each pair under the command of an officer, or sergeant. Each gun must have a non-commissioned officer as gun commander.

2. They should usually be placed in rear of the second or support line, and between it and the third line.

3. They should be able to fire either by direct or indirect fire:

(a) On No Man's Land, bringing oblique or enfilade fire in front of the posts which constitute our first line. This is usually achieved by laying the lines of fire so that they pass between the posts and cross in front of them, i. e., by the locking of beaten zones as described in Section 14, Type B.

(b) On the ground between the front and support lines, putting bands of fire across it, as described in Section 14, Type A.

22. Guns In or Near the Front Line.

As stated in Section 21, Paragraph 2, the forward guns should not normally be placed in front of the support line.

In exceptional cases, however, it may be desirable to place one or more forward guns in or near the front line, e. g., (a) Where the Infantry is holding the far side of a village, wood, or stretch of open country, with a wide sweep of open ground in front offering excellent lines of machine-gun fire; (b) Where guns in the front line are defiladed from the enemy by rising ground, and are able from this vantage point to bring fire on important roads or trench junctions further down the line.

In all cases where guns are in or near the front line, they must have local protection against surprise, in particular by enemy bombing parties. A party of friendly bombers and riflemen should always be at hand, and a bombing post established to prevent approach within bombing range of the gun positions.

23. The Barrage Guns.

1. These guns will usually be placed in the neighborhood, and in rear of, the third line or main line of resistance.

2. The ideal programme for these guns would be:

(a) To provide a complete S. O. S. barrage line along the whole front; this line is to be normally 200 to 300 yards beyond the artillery barrage line.

(b) In the event of a hostile penetration beyond the second line, to place bands of fire across the front of the strong points in the third line. These bands should be so arranged that the fire comes between the strong points and crosses in front of them. Where the number of guns does not permit the first part of the programme to be carried out completely, arrangements should be made in conjunction with the Artillery (see Section 17, Paragraph 3) to put the S. O. S. barrage on selected parts of the front.

3. The barrage guns will usually be the guns employed for covering raids and other special enterprises, such as gas projection. They will constitute a mobile reserve which will be in readiness to cope with emergencies on a particular part of the divisional front, or on the front of the divisions on either flank. The fact that they are not involved in the close defense of the front line will facilitate

conference with the Artillery, and their detachment for special tasks.

24. Night Firing by Forward and Barrage Guns.

1. In normal times the bulk of machine-gun firing will be done at night. The execution of night firing must never be allowed to become a mechanical and perfunctory performance. In this work it is possible, even when the general situation is quiet, to maintain the offensive spirit.

2. The targets must be well selected and the volume of fire sufficient. The requisite intensity of fire should be obtained by increasing the number of machine guns, rather than by allotting bigger tasks to a restricted number. Both classes of guns, therefore, forward and barrage, will be employed.

3. Each night-firing should be part of a programme, which is based on the information obtained by the divisional machine-gun officer from the latest intelligence and the night-firing programme of the artillery; the results being communicated to him for co-ordination and development. (See Part III, Section 4.)

4. Provided that an alternative position is available in case of need, it will usually be safe, and always more convenient, for guns which have well equipped S. O. S. positions concealed from view, to do their night-firing from these. But guns whose S. O. S. position is exposed, or very close to the front line, must move elsewhere for night work.

5. The difference between normal night-firing and the harassing fire carried out mainly at night-time, prior to a set-piece attack (see Section 8), is merely one of degree. The methods and organization are identical.

25. Defense in Depth and the Offensive Defense.

An observance of the principles laid down will result in a zone of machine-gun defenses organized in depth rather than a series of positions covering, and limited to successive trench lines. The object of placing machine guns in depth is to secure fire in depth from the enemy's front system back to our own reserve lines; but the guns themselves should not be dotted indiscriminately over the zone, as they will then not be amenable to fire-control, and therefore not flexible. Control and flexibility are essential to the "offensive" defense mentioned in Section 23, Paragraph 3, and Section 24 above. For this kind of work, and the set-piece offensive itself, the machine guns must always be prepared. A system of purely passive defense is destructive of efficiency, and furthermore overlooks the important function of inspiring the Infantry with confidence.

26. Fire Control of the Forward Guns.

1. These guns should, where possible, be sited in pairs. Direct observation of the situation from the gun positions, and fire on previously arranged S. O. S. lines, will, as a rule, be the only method of control once the enemy attack has commenced.

2. In order that the guns may be able to fire as directed in Section 21, Paragraph 3, there will be two prescribed lines of fire, of which the first will bring them on to No Man's Land as described in Section 21, Paragraph 3 (a): while to the second they can be switched without delay as described in Section 21, Paragraph 3 (b). Fire will be opened on the latter, as soon as it is ascertained that the enemy has penetrated beyond the first line, into the vicinity of the second line, and the situation as regards our own troops is sufficiently clear.

Until then fire will be maintained on the S. O. S. line, and the

barrage thus formed, combined with that of the barrage machine guns and of the Artillery, should prevent the enemy being reinforced, and enable the infantry to deal with those of the enemy's troops which have succeeded in entering the front position.

3. Precise instructions must be issued as to the fire of these forward guns, and their action and lines of fire in case of an attack explained to the Infantry. The part played by machine guns in the defense of the sector should be explained and illustrated in the divisional defense scheme issued by the general staff.

4. In an entrenched position, the ability to repulse the enemy does not depend on the number of men in the trenches before the bombardment begins, but on the amount of fire that can be delivered against the enemy when his barrage lifts and his Infantry advances. If the trenches are thickly manned by Infantry:

(a) Heavy loss is caused by the bombardment.

(b) Difficulty is experienced by the forward machine guns in bringing fire to bear on the enemy without hitting their own Infantry.

These disadvantages are reduced to a minimum when the first second lines are held lightly by the Infantry, and arrangements exist between them and the machine gunners whereby certain portions of the trench system in, and in front of, the second line are marked as being in the danger zone of machine-gun fire from the moment the S. O. S. signal goes up, as well as later when the machine guns are firing on their second lines of fire in the manner just described.

The routes by which Infantry will move between the first and second lines should be definitely laid down, and known by the machine gunners.

Arrangements of this nature will enable the full power of the machine gun to be developed from the beginning of the attack and maintained throughout. Large areas of ground will be denied to the enemy, his attack will be kept "below ground," i. e., confined to working up the trenches themselves, and the task left to the Infantry of dealing with those of the enemy who have penetrated beyond the first line will be facilitated.

6. Thus, by careful arrangements, precise instructions, and a thorough understanding between the Infantry and machine gunners, it will be possible to ensure that confusion, delay in opening fire and risk to the Infantry from the fire of their own machine guns, are minimized, and the Infantry will be able to rely on obtaining support from the machine guns from the outset of the enemy attack.

27. Fire Control of the Barrage Guns.

In a similar manner the barrage guns will primarily have two lines of fire:

(a) On their S. O. S. line.

(b) On their close defense line.

Fire will be maintained on the S. O. S. line until it becomes evident that, owing to the advance made by the enemy, fire at close ranges is necessary in order to protect the third line.

Fire on the S. O. S. line, in conjunction with that of the Artillery, should prevent the enemy being reinforced, and thus enable the infantry and forward machine guns to deal effectively with those of the enemy who may have succeeded in penetrating the front position.

28. S. O. S. Signal.

It will rarely be possible for the barrage guns to have their

fire controlled by direct observation from the vicinity of the gun position. Communication by runner is obviously out of the question, being far too slow for S. O. S. purposes. Visual signalling and telephonic communications are the only alternatives. The normal method of signalling an attack is the sending up by the Infantry of an S. O. S. rocket. This is excellent provided it is observed, but it is a very common experience that the S. O. S. signal is either missed or misunderstood. The machine guns cannot afford to wait until they hear the artillery opening up; for it is the role of the barrage machine guns to open fire on their S. O. S. lines the moment the attack is signalled, and, if possible, before the enemy have penetrated our wire. The greatest value of these guns is in the first two minutes of an attack, and they must aim to get their fire down more speedily than the Artillery, and even before the very lights have been burnt out.

It is therefore necessary that there should be liaison between the machine guns and the Infantry, who send up rockets. All machine gunners must know what the light is, from whereabouts it will be fired, and in what direction. Picking up the S. O. S. signal should be frequently rehearsed on field ranges, when units are out of the line. If there is any risk that the S. O. S. signal will not be picked up by the barrage guns, a forward observation officer, connected with these by telephone, should be stationed in front. There are numerous examples of the successful results of such an arrangement.

29. Telephone Communications.

1. No proper system of fire control is possible without telephonic communication. (For details see Part III, Section 4.)

2. In addition every effort should be made to link up by telephone pairs of forward guns with their report centers, of which there should be two or more in each brigade area, connected up with the forward observation post and the officer commanding machine guns in the manner just described.

The report center will usually be a battalion headquarters (see Section 4, Paragraph 16) and therefore, when separate lines are not available, it should be possible to arrange that the forward guns can send and receive messages from the headquarters of the nearest Infantry company over the battalion lines.

3. Communications with the rear, via the divisional machine-gun officer, puts the guns in immediate touch with information from the Artillery, the Royal Flying Corps, and adjacent divisions.

4. It is only by the above means that it will be possible to make the machine-gun defense flexible, rapid in execution, and of the greatest value to the Infantry.

30. The Battery System.

1. The battery system, i. e., a group of guns usually eight in number under the control of a battery commander, is an established feature of barrage work in offensive operations. The system is equally applicable to the defensive barrage. It is possible that here a battery of four guns, which is less easy of detection, may be a large enough unit under normal conditions, but the better the communications, the more elastic the battery system can become, without sacrificing its fundamental characteristics—unity of control.

2. An arrangement of the main line defense on the battery principle has these advantages:

(a) It fits naturally into the scheme of distribution in depth.

(b) It saves much time that is otherwise spent in the tour and inspection of isolated gun positions.

(c) It reduces to a minimum the difficulties of ammunition supply.

(d) It makes the system of defense more flexible. The barrage guns will be available for other work than fire on a single S. O. S. line. Their fire can be switched on a new danger zone, in response to calls from the divisional machine-gun officer or forward observation officer. The speedy diversion of the concentrated fire of many guns is the most telling fashion in which the surprise effect of machine guns can, under existing conditions, be attained.

(e) It makes the machine guns a better instrument for co-operation with the Artillery in the "offensive" defense.

3. A combination, consisting of the minimum of forward guns consistent with their being able to perform the duties already outlined, and of barrage guns organized on the battery system, will be found a good working combination under most circumstances, especially when the defense is that of newly won ground, where little or no protection for forward guns exists.

31. Sniping Batteries.

(a) A battery connected by telephone with a forward observation station can be employed as a sniping battery. By the aid of his fighting map (see practical workings of M. G. Barrage) the forward observation officer is able to send down the necessary fire orders in a simple form in the minimum of time. On many parts of the front visible targets are rare, but after an offensive they are often numerous, and where sniping batteries have been employed on these lines they have obtained good results.

Trained observation is indispensable. The observer who is conversant with the principles of the enemy's scheme of defense (see Section 39), will be able to locate targets from momentary glimpses and casual hints which would be lost on the uninformed observer, however keen his eyesight.

The reporting of targets, and of fire effect (when this can be observed) gives confidence to the machine-gun personnel, and at a minimum cost in material stops overland movement by day within machine-gun range.

(b) Retaliation Maps.

The group commander of the barrage guns prepares a map for the Infantry commander of the sector, who, when he is bothered by enemy harassing fire, as from trench mortar, for instance, telephones map reference to group commander, and a battery is immediately swung on to the target, reference being made to the fighting map of the battery. (See Appendix E.)

32. Siting of Machine guns.

1. Guns must be sited with reference to the role they have to play in the scheme of defense. One of the disadvantages of putting guns in the front line is that the gun position has to conform to the trench line, and all work on it is subject to continuous enemy annoyance and supervision, and to complete destruction in cases of an intensive enemy bombardment. The position is therefore likely to be weak, tactically and materially.

A site, well in the rear of the front line, can be selected in the strongest tactical position, and the strong points or trench lines can be planned to conform to the site on the machine guns.

2. In general, owing to the concentrated Artillery fire which is likely to be directed on it, positions in a clearly defined trench system should be avoided. Aerial observation, however, makes the concealment of positions in the open increasingly difficult. Such a

position should not be completely surrounded by belts of high wire, which palpably indicate its position to the airmen.

During the process of construction, the excavation and building materials should be carefully camouflaged. Even though all movement takes place at night, tracks may be made which show up most conspicuously on photographs. It is therefore often advisable to select a site near a piece of trench system and use this as an avenue of approach. The track from the trench to the position can then be continued past the position, to a trench beyond it, and made to resemble a new short cut in the existing trench system. Tracks may be avoided by using duck boards or canvas strips.

3. Mobility, alternative positions, and frequent changes of location are, along with camouflage, the best ways of ensuring concealment. The further the guns are from the front line, the less the difficulties of moving. A change of position will be imperative for a battery of guns, if there are clear indications that they have been spotted.

4. Machine guns and protective wire should be sited with reference to each other. Wire entanglements should be arranged so as to force the enemy in a particular direction, which will bring him into a belt of machine-gun fire.

It is not advisable to place machine guns in the angle of the wire, where the enemy is bound to suspect their presence. Only dummy emplacements should be constructed at these points, the actual machine-gun emplacement being sited in concealed ground to a flank or in rear.

In the laying out of new field works and new wire, close liaison between the engineers and the machine-gun corps is of paramount importance. (See Section 17, Paragraph 4, and Section 36, Paragraph 5.)

5. (a) The slope of the ground is always an important consideration in the siting of machine guns; and for the machine gunners the choice of slope will usually be liberal when the scheme of defense is in depth, and the ground is surveyed from the standpoint of the division and corps.

(b) A forward slope offers the big advantage of direct laying and continuous observation of the movements of troops, in case the guns have to change from long-range indirect fire to direct fire across their immediate front. The serious drawback is the risk of detection from enemy observation posts or balloons, and the difficulty of moving while under observation. Where the position on the forward slope can be ingeniously concealed, it may, by its inherent improbability, escape Artillery fire.

(c) A reverse slope now presents no serious drawback to overhead fire. Its advantage is that it allows of unobserved movement up to the position. When guns are in a battery, it also conceals the unavoidable traffic between gun and gun, but because of its natural advantages it is likely to be marked down by the enemy's Artillery and (if it is an isolated feature) to be subjected to a concentration of fire.

(d) The ideal slope is, perhaps, one defiladed from the front and sloping obliquely to the enemy. This kind of slope is more likely to offer itself in a hilly country with spurs and intersecting valleys. The guns can then be sited so that they enfilade any attempt to cross the valley, and with frontal fire prevent the enemy ascending it. Care must be taken in these cases that the tops of the ridges are commanded by guns placed in other positions.

13. Types of Emplacements.

(See "Notes on Field Fortifications"—Appendix.)

1. The type of emplacement selected will be governed by the role of the gun, the lie of the ground, the labor available, and the nature of the cover.

2. Covered Loophole Emplacements.

These, when built into a clearly defined trench system, (as contrasted with strongholds in woods and industrial areas), are seldom suitable now-a-days. Even strong concrete will not stand a modern bombardment, and the loophole faces get knocked about, or blocked up, or masked, by shell debris. In sandy ground there is an additional drawback.

Unless the floor of the loophole emplacement is made of solid material and kept swept of sand hourly, the draught, when the loophole screen is lowered, drives a cloud of sand on to the gun and into the firer's face. Furthermore, the cordite fumes from certain makes of small-arms ammunition are injurious to the gun numbers confined in such an emplacement and will necessitate the wearing of respirators during firing. On the other hand firing under cover in addition to reducing minor casualties, increases the gunner's confidence.

Covered emplacements will often be found suitable:

(a) In naturally protected places such as woods, houses, and mine buildings.

(b) In battery positions, when these are sited on reverse slopes, from which the work of construction will not be visible to the enemy. In this case there will be no loopholes. (See diagram in Appendix II.)

3. **Open emplacements**, connected by covered way or open trench with neighboring emplacements and a central dugout.

The advantage of this type is that it is easily constructed, so that numerous alternative positions can be prepared in advance. In battery positions the open emplacement facilitates fire control, setting out of aiming posts, and laying off from reference objects.

If, however, the central dugout is any distance from the emplacements, there is a danger that the teams will never reach them under a bombardment.

The most modern form of open emplacement is the adapted shell-hole, or series of shell-holes; which from their resemblance to the surrounding terrain are difficult to detect. Open emplacements must have limits of traverse.

4. Emplacements of the CHAMPAGNE Type.

The plan is a double shaft leading up from a dugout between the two. One shaft is the entrance, and from the other shaft the gun is fired.

There is therefore no distance between the dugout and the gun position. The firing shaft opens into a shell-hole, or bit of natural cover, or on to a carefully camouflaged slit in the ground. In isolated positions, or positions covering strong points this is generally the best type of emplacement.

A strong tunnelled system leading out to inconspicuous emplacements, which are little more than stances for the gun, combines many of the advantages of the covered and open emplacements. Weak tunnels, however, are only traps.

5. Observation Posts Providing Cover for Sentry.

14. Equipment of Gun Positions.

Whether in actual occupation or not, all gun positions, other than alternative positions, should be equipped with the following:

1. Order board.)
2. Lists of stores.) See Appendix I.
3. Fighting map.

4. Intelligence summary. (Occupied positions only.)

The fighting map should show the zero line, line of fire for S. O. S., line of fire for defense of trench near which the position is sited, and the line of fire of the guns on either flank.

The intelligence summary should contain:

(i) The calculations from which the fighting map has been made.

(ii) List of targets (with calculations), for harassing fire.

(iii) A record of all fighting done and the targets engaged.

(iv) Notes on the ground visible from the gun position.

(v) Position of section officer's dugout, and the machine-gun company headquarters.

(vi) Information as to relief, dumps, etc.

Wherever possible gun positions should be provided with a shelter for belt filling and gun cleaning and also with a dugout for the gun team. Recesses should be constructed in which to keep the gun, spare parts, and belt boxes. One of these recesses should be made gasproof and at least half the belt boxes and the gun kept in it.

APPENDIX I.

RELIEF OF A MACHINE GUN COMPANY.

1. The same principles for relief apply both in trench and open warfare, so that in this section trench warfare will be discussed.

2. Two or three days previous to a relief a warning order will be issued by the higher command to both your company and the company you are to relieve, usually stating that necessary details of relief will be arranged by commanding officers of machine gun companies concerned. On receipt of such warning you should at once arrange to visit the company commander you are to relieve in the trenches and take along with you your platoon commanders. If possible this should take place 48 hours before the time for relief as this gives you a clear day after your reconnaissance to make necessary arrangements at your headquarters. If it is your first tour in the line or a new and peculiar sector, arrange for one representative per gun team to go into the line twenty-four hours ahead and live with the team he is to relieve.

No officer ever goes into the trenches without a personal orderly.

3. On arrival at company headquarters of the company you are to relieve, arrange for your platoon commanders to be taken to the headquarters of the platoons they will relieve.

4. The Company Commander's Reconnaissance.

Do not pester the man you are to relieve by a string of questions; make a note of points on which you require information and tick them off as dealt with.

A trench reconnaissance must be sociable.

The following are the points on which you must receive definite information for the company commander:

(1) Position of company and platoons headquarters with accommodation at each.

(2) Position of guns and fields of fire, including flank guns of flank companies—these should be marked on a trench map and handed over.

(3) Sector defense scheme.

(4) Nature of the enemy.

(5) Position of machine gun dugouts and accommodations at each.

(6) Position of extra emplacements used for any special enterprises.

(7) Special harassing schemes.

(8) Position of any observation posts.

(9) Dumps and their establishments.

(10) Water supply.

(11) Special orders as regards fires and lights.

(12) Particulars of any work in progress which will not be finished before the relief.

(13) Aeroplane photos.

(14) Arrangements for taking over tripods or belt boxes.

(15) Most suitable time for relief and arrangements for guides. This must be most detailed and carefully arranged. Not only darkness but time of enemy's evening hate must be allowed for.

5. Platoon commander's reconnaissance is more detailed than his captain's, but embraces the same points for his platoon; in addition he will ascertain the following:

(1) Vulnerable spots in his line.

(2) Vulnerable spots in the enemy's line.

(3) Usual emplacements where night firing is carried out—which ones were last used, when, and against what targets.

(4) Inventories of stores to be taken over at platoon headquarters and at the gun positions.

6. On return from the trenches to billets, discuss the relief with your platoon commanders, and instruct your second in command upon the drawing up of field orders for issue. These orders should contain detailed instructions for platoons, including orders for transport with notes as to safety precautions on the roads. Platoon commanders should then have an opportunity of reading their orders in your presence to ask questions if necessary. Do not forget to send a copy of your relief orders to the company commander you are to relieve.

7. Relief of the Gun Squad.

The duties of the N. C. O. or gun number in charge of each gun are as follows:

(a) See that nothing is left behind in the gun carts, and that everything arrives at the emplacements. He should walk in rear of the squad, and see that nothing is dropped or left behind.

(b) To take over and check all Trench Stores in the emplacement or dugout (S. A. A., order board, range card, anti-gas appliances, etc.). Receipts should be given and taken in all cases.

(c) To notify the platoon officer on the completion of the relief.

(d) Find out from squad leader relieved general scheme, shortest route to platoon headquarters, position of flank guns, alternative emplacements, latrines, shelters, dumps, latest firing—when, where from, and what on.

(e) Explain all details to the gun squad.

8. Relief complete will always be notified in code; and platoon commanders, on receipt of reports from squad leaders, notifying company commander by wire, confirming later by orderly with written report and copies of taking over certificates.

LIST OF STORES BELONGING TO THIS GUN POSITION.

Article.	Numbers	Remarks.
Fighting Map or Range Card.		
Barrage Chart.		
Intelligence Summary.		
Mountings. (pivot box wooden base, etc.)		
Mill's Grenades.		
Picks.		
Shovels.		
Refuse Tin.		
Sundries.		
Date.....		

MACHINE-GUN OFFICER.

APPENDIX V.

NOTES ON FIELD FORTIFICATIONS.

SECTION 1.—GENERAL RULES.

1. (a) A machine gun officer should not attempt without expert assistance or advice to do work which is beyond the scope of his engineering technical training.

(b) He should not rely on the engineers to do work of a technical machine gun nature, such as setting of loopholes, height and size of platforms, etc.

2. Co-operate with the technical services. They can give much material and help which is otherwise difficult to obtain.

3. When about to be relieved, write down a list of work in progress, preferably in the form of a sectional and plan drawings. These should be handed over to the incoming platoon officer with any additional notes that may be of assistance to him.

4. Even if a machine gun platoon is being relieved the following day, essential repair work to the portion of trenches occupied must not be postponed.

Leave the trenches occupied clean and dry, and in as good repair as possible.

5. Small repairs if taken in hand in time, both to emplacements and trenches leading to them, will always repay the trouble taken.

SECTION 2.

HINTS BASED ON RECENT EXPERIENCE.

1. There are seldom enough emplacements in any given trench system.

2. Many machine gun emplacements are disclosed by the obstacles placed in front of them, and thus destroy surprise effect.

3. Concealment from aircraft of work under construction is essential. This can most easily and effectively be done by the use of wire netting stretched above the work and bunches of grass, sandbags, or brushwood tied on to it.

4. When chalk is being excavated from beneath surface loam, it must be removed from the neighborhood of the work. All tracks and paths must be covered up which lead to emplacements. They will eventually disclose the position of the emplacement.

5. More time is wasted by working parties running short of material than in any other way. Always make certain before undertaking any work that the necessary material is available.

6. When possible, it is usually better to prepare woodwork used in construction, behind the line and carry it to the site of the work ready for use.

DUGOUTS.

The result of observation of the effect of direct hits from high explosive shells or Minenwerfer projectiles on deep mined dugouts, tends to show that if the roof is well supported, 12 feet to 14 feet of chalk or sand, and 17 feet to 20 feet of loam, it affords adequate protection against 5'9 or even 8 inch shells.

The entrances of mined dugouts are the weakest points. Aim at securing at least 6 feet of head cover above the first frame, and see that the frames near the entrance are strong and braced. The trench at the entrance of the dugout should be provided with overhead cover, and struts put in to prevent it collapsing and blocking the entrances. Always insist on at least two entrances at each dugout.

The minimum size of a dugout for a machine gun team should be 8 feet long, 6 feet wide, and 6 feet high. The stairs should have frames at least 4 feet, 6 inches high, by 3 feet wide, and be made at a slope of 1/1.

Do not attempt to make a dugout with mined entrances, without some expert assistance. Once it has been properly started, and the direction and slope of the entrance secured, it can be continued without much further help.

Always keep a pick and shovel in every deep dugout.

If the "elephant" shelter is going to be used, see that the excavation for it is sufficiently deep to enable 2 feet to 3 feet of earth to be put on top, as well as a bursting layer, covered with 6 inches of earth. This means that the excavation must be at least 11 feet deep. A timber frame work which does not quite touch the inside of the roof of shelter will greatly reduce the concussion caused by a direct hit on an "elephant" shelter.

EMPLACEMENTS.

(1) **Open.**—Minimum size for all round traverse 4 feet by 4 feet, unless recesses are made in the parapet, into which the legs of the tripod can be fitted. Height from table to top of parapet 15 inches to 18 inches.

If the emplacement is constructed to shoot to a flank, see that the loophole is properly defiladed. Minimum size for a fixed line of fire 3 feet, 6 inches by 4 feet.

Emplacements sighted behind the parapets, and approached by a short trench leading from the main trench are frequently the most effective in advanced positions. They are well concealed, and owing to the presence of Infantry in front, give additional confidence to the gunners.

Ammunition Box Mounting.—Cut a hole in the lid to fit the pintle and a block fixed to the bottom of the box on which the end of the pintle may rest. The box must be clamped to a 9 inch or 12 inch plank about 4 feet long, and the plank then built into the parapet.

Shell Hole.—Is the normal type after an attack, and popular owing to protection from hostile observation and speed of construction.

Front legs of tripod are dug into side of shell hole and small sandbags platform construction for the trail leg. Care must be taken not to alter the surface of the shell hole, though it may be deepened for shelter as much as desired.

(2) **Splinter-Proof.**—About 2 feet of earth gives protection against shrapnel, fragments of high-explosive shells or bombs.

(1) Always sight the loophole first and as low as possible this will enable the depth of excavation necessary to be decided upon.

(2) Excavate the required amount of earth; do not disclose its position, and remove the earth some distance away.

Make a rough section and plan of the emplacement it is proposed to construct, and calculate the amount and sizes of the material required.

A chamber 5 feet long, 4 feet wide, and 4 feet high, is the minimum.

The minimum size of the loophole is 3 inches by 3 inches; if using a muzzle-pivot mounting, leave room above this to enable the rear cover of the gun to be raised. The minimum for a Vickers gun is 15 inches.

In making a loophole 5 feet of earth are required to stop a bullet, and if this can not be obtained, use one-half inch steel plates around the loophole. Deflate or conceal the loophole with sandbags or other material.

(3) **Reinforced Concrete Emplacements.**—Do not attempt to construct without expert assistance. Insist on a double roof separately supported, and an air space of at least one foot.

The importance of a bursting course has been abundantly demonstrated but see that it comes well over the sides of the emplacement, and that it is not covered by more than 6 inches to 9 inches of earth. If there is more, it tends to act as tamping to the explosion. There should be at least 2 feet of earth between the bursting course and the roof.

SUGGESTIONS FOR MACHINE GUN OFFICERS.

- Remember that cover from view is more important than cover from fire.
- During construction work and materials must be camouflaged against aero observation.
- Drainage and sanitary arrangements must be considered.
- Maintain such relations with infantry that when necessary you can obtain working parties from them, in which case state to Infantry commanders:

- (1) Number of men wanted.
- (2) How long.
- (3) Tools needed.
- (4) Rations and so forth.
- (5) Time and place to report.

- In average soil excavations are as follows:

1 man	4 hours	80 cubic feet
		30 cubic feet 1st hour.
		25 cubic feet 2nd hour.
		15 cubic feet 3rd hour.
		10 cubic feet 4th hour.

Illustrations of types of emplacements, dugouts, etc.

PLATE 3

Special Emplacement in Traverse of Fire Trench

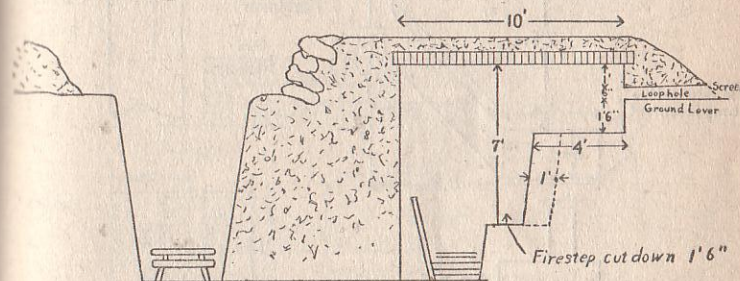
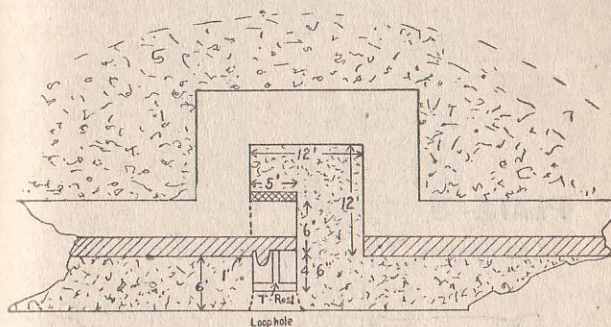


PLATE 4

Simple Covered Emplacement (Splinter-proof)

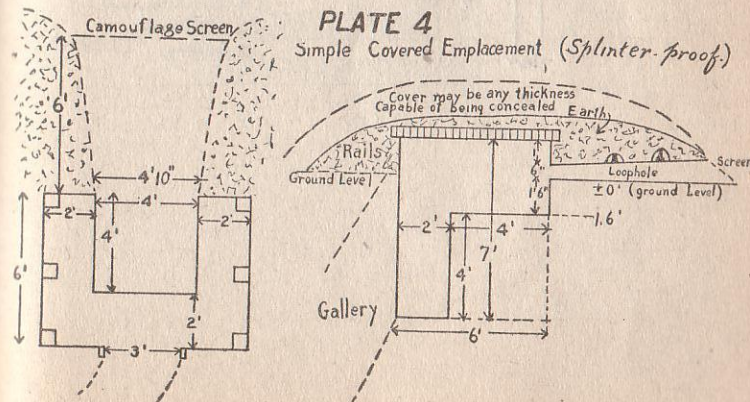


PLATE 5
Champagne Type Emplacement •

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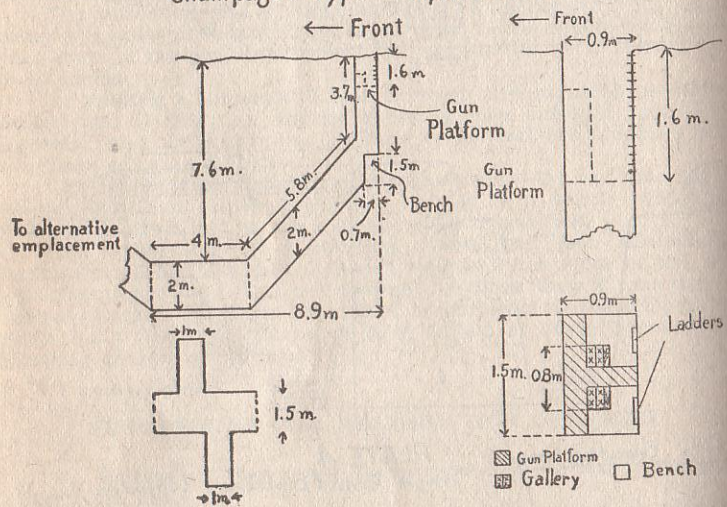
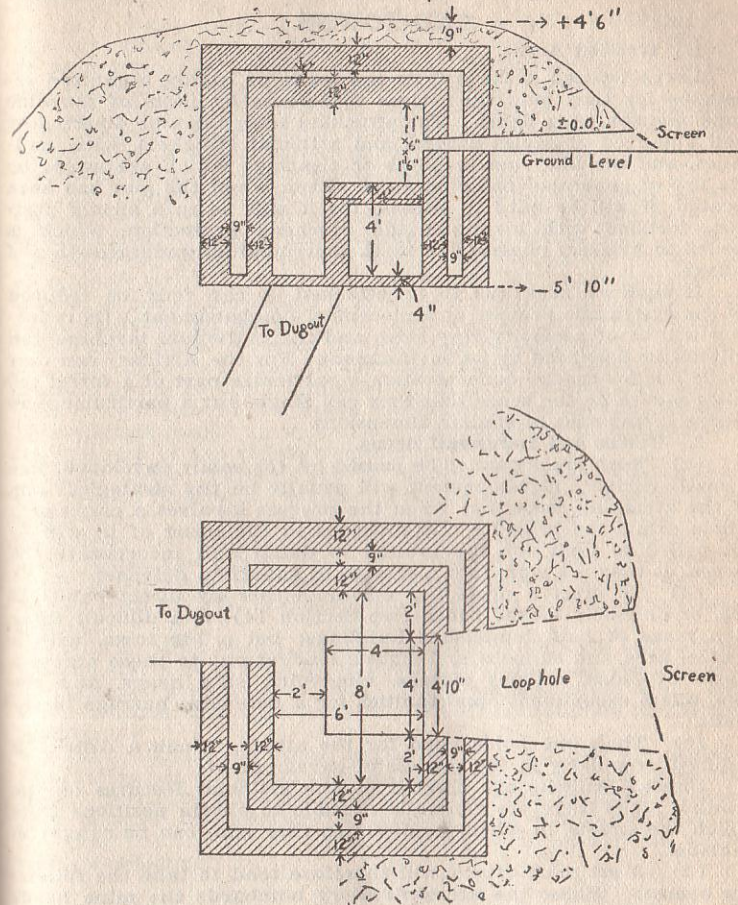


PLATE 6

Concrete Emplacement



CHAPTER IV.

35. ATTACK AND DEFENSE OF WOODED AREAS AND TOWNS.

1. Wooded Areas.

Large wooded areas will be the scene of highly organized resistance for they lend themselves to defense by nests of machine guns, distributed in depth. The attacking troops can be diverted by well arranged obstacles natural and artificial (thickets, wire, palisades, and the like), on to paths or clearings which are swept by the fire of concealed machine guns. Even when the gun has been located, it will be hard to silence, for it will be in a strong position, fortified with loopholes and overhead protection, which is denied to Artillery observation by the surrounding undergrowth and foliage.

If such an area has to be attacked, it can only be reduced by the systematic process of a piecemeal bombardment. Its reduction will be of necessity very slow, and the individual machine gun will not be penalized by its environment. For the Artillery can only single out for special concentration a particular part of a forest ten miles square, in the sense that they can single out a particular map square in any area of similar dimensions.

2. Towns and Industrial Areas.

(a) Such areas cannot be passed by (or easily enveloped, like a small village. Envelopment will usually be the strategical aim of the attacking force, but when the process involves a corps or a whole army, the brigades and divisions in the heart of it, will be compelled to fight for the ground in detail and incorporate the pieces, as they are won, into a scheme of suburban defenses.

(b) To erect a protective curtain either by direct bands of fire, or obliquely locked zones (see Section 14), is a difficult thing in a maze of half demolished buildings; but a big town, with a central area and suburbs and streets leading out to those across a waste of fields, railway sidings, reservoirs, slag heaps, and the like, offers exceptional opportunities for a defensive barrage in enfilade.

(c) The same holds good for the attack. Such a district is reduced irregularly in the process of envelopment.

Unusual salients are created by the artificial features on the ground. It is therefore generally possible to obtain positions from which the streets, in whatever direction they run, can be caught in enfilade.

(d) A set piece attack will therefore tend to take the following course: Whilst the heavy Artillery bombards the mine heads (Fosses, Puits, etc.), public buildings, chateaus and street rows, the machine guns will supplement the rolling barrage of the field Artillery by placing an enfilade barrage along slag heaps, avenues and streets. The occupants of the houses, if they try to run away, will either be caught by machine-gun fire, or confined to the tedious and dangerous course of working from ruin to ruin. All traffic junctions within range and strike of the bullet (the two things are by no means identical), will be similarly swept.

(e) Frontal fire on roofs and walls is very demoralizing to the occupants. It will therefore be advisable to combine frontal with enfilade fire.

As this kind of frontal barrage is mainly for moral effect, each gun can be given a bigger frontage than usual, say 100-150 yards, and this will free more guns for the enfilade of different streets.

(f) A rain of harrassing fire at night, planned on the same principles, and incessantly maintained, will greatly lower the spirit of the defense.

(g) When machine guns are located within the building area, reference objects are usually very hard to find. Often nothing can be seen from the position except the immediate field of fire, so that the gun must be laid for indirect fire by compass.

(h) As a site for machine guns, a house is to be avoided if it is an isolated cottage, or if it abuts on cross roads, but when it is tucked away among scores of similar houses, or forms part of a composite group, it offers certain advantages:

(i) The cellars make dry and comfortable dugouts, and when they have been in enemy occupation, many will already have been strengthened. In this case, however, precautions must be taken against booby traps. The ventilation holes facing the enemy must be strongly covered, and when captured buildings are first entered, it must be remembered that it is the enemy's custom to block up the front windows and leave gaps or open windows in the rear, through which the light of a match or torch will be detected.

(ii) Provided that it has been strutted (which usually is feasible owing to the abundance of mine props and derelict wood work), the basement of a house will sometimes withstand a direct hit on the house itself. In that case the growing pile of bricks adds to the strength of the collars beneath.

(iii) Cellar windows afford natural loopholes in abundance, and require little or no external work before use as a machine-gun emplacement. If they become masked by shell debris it is usually possible to find without much difficulty an alternative position outside. While the gun is inside or outside the cellar, care must be taken to keep the gun and ammunition clear of brick dust while mixing with the oil, forms a paste that clogs the working parts of the gun.

NOTE: The enemy makes a practice of building concrete emplacements in a ground floor room and firing his machine guns through the window or a hole. These emplacements are a room within a room, and apparently capable of withstanding the heaviest shelling.

(iv.) Where the upper stories are standing they are useful as observation posts; and on occasions machine guns can be fired from them. Instances have occurred in which machine guns so placed have covered the advance of Infantry with direct overhead fire, sweeping the top of the Fosse or other point, which was the Infantry's objective.

CHAPTER V. CONSOLIDATION.

36.

1. The principles of consolidation in depth of ground won are identical with those that govern the placing of machine guns in a system of highly organized defenses.

2. The mobile guns, whose role during the offensive has been detailed in Section 4, become the forward guns of the defense, and they will be sited with a view to carrying out the same duties. As they move up to their selected positions in the manner already described, these guns, in conjunction with the barrage guns following on behind, will at no stage violate the principle of a distribution in depth, and from the outset of their location in a new environment will assume naturally a role similar to that which they have discharged in the settled warfare of the trenches.

3. In the plan drafted before the opening of the offensive operation, the several problems relating to the position of advanced posts, shell hole defenses, the joining up by trenches of defended shell holes and strong points, the line of connected strong points in rear, the position of the mobile guns and the barrage batteries, will have been considered as a whole, and the disposition now taken will conform to the arrangements then made.

4. These arrangements will contemplate a scheme of defense of the same type as before (see Section 13), namely:

(a) A series of defended shell holes, etc., not forming a continuous line, corresponding to the FIRST LINE in ordinary trench warfare, and defended by Infantry and Lewis guns.

(b) A line of strong points connected up by trenches, corresponding to the SECOND LINE, and occupied in greater strength.

(c) A further line of strong points, or converted enemy entrenchments, corresponding to the THIRD LINE.

5. The reconnaissance for the mobile guns should be made in conjunction with the reconnoitering detachment of Engineers which follow in the wake of the attacking Infantry. When the gun teams reach their destination, their function will be two-fold.

(i) To cover the Infantry and working parties of pioneers who are engaged in the construction of strong points and lines of resistance.

(ii) To co-operate with the engineers in laying out machine-gun fields of fire, and constructing machine-gun emplacements, the object being to secure a sequence of work, in which as the initial stage, machine-gun fields of fire are selected with reference to the possibilities of the ground, and themselves determine the conformation of the protective wire which the engineers are proceeding to lay.

When the process of consolidation is sufficiently advanced, the guns will, where necessary, move from the positions temporarily taken up in the course of the battle, to those allotted to them in the newly constructed system.

6. The mobile guns thus become forward guns, and, as such they will be located normally between the SECOND and THIRD LINES. As before, they will have two lines of fire:

(a) Between the advanced posts of the First Line on to the ground in front, which they will protect with a screen of Type "B," as described in Section 14, and Section 12, Paragraph 3.

(b) Along the ground in front of the Second Line, which they will protect with bands of short range fire.

As the advanced posts do not form a continuous line, their power of resistance will be strengthened without risk to the occupants, by machine guns firing between them from the rear.

7. The forward movement of the barrage guns (see Section 10) demands the same judicious timing and foresight.

(a) There is no question of their being able to cross No Man's Land before the enemy barrage comes down. An hour or so after zero, they must pass through this barrage, thick or thin. Therefore, as much latitude as possible should be allowed to them as regards the moment at which they will move forward.

(b) Whereas the mobile guns will sometimes never be called upon to fire a shot throughout the whole battle, the fire of the barrage guns at their intermediate positions is an essential part of the battle action, and either from there, or from their final positions, they will nearly always be called upon for an S. O. S. barrage. Every effort should therefore be made to avoid selecting positions

on the enemy's barrage line. The fact that the enemy will naturally select for his barrage distinctive lines like a support trench, a road or a river, must be set against the temptation to send the barrage guns to these easily recognizable features.

If the barrage guns have the misfortune to strike the barrage line, they must either take shelter, and thus make default in this part of the program or move elsewhere in order to fire. The latter course involves the working out of new calculations, which is a difficult matter in the stress of an action, even for a highly trained personnel.

(c) The divisional machine-gun officer must carefully lay down beforehand the status of the barrage guns after an attack, whether and when they are to split up and return to their defensive formation. Even when the battery system is maintained as a normal part of the defensive structure, thinning out of batteries, etc., will usually be necessary.

(d) Owing to the strain, physical and nervous, which is imposed on a team that has first of all to fire a timed barrage and subsequently to keep on the alert for S. O. S., calls their relief should not be delayed, this having been arranged in advance in accordance with Section 6, Paragraph 3. When fresh divisions are holding the new line, they will be apt to press for the retention of the old personnel, who are familiar with the situation. But all experience is against the policy of keeping the same teams in the same barrage positions for as much as a week after the attack.

(e) The scheme of consolidation will be rounded off by the final location of the barrage guns in rear of the new Third Line. There they will resume a defensive role, two-fold in nature, corresponding to that which they occupied before the advance. (See Section 22, Paragraph 2).

CHAPTER VI. WARFARE OF IMPROVED DEFENSES AND OPEN FIGHTING.

37. Special Considerations.

1. Important as are the organization and arrangement of the work of machine guns in warfare against highly organized defenses, they are even more important after the main defended area has been broken through, and the fighting has resolved itself into the attack and defense of more less hastily defenses.

2. The more open the fighting becomes, the more will troops get away from "the mass" of their Artillery, and have to depend on machine guns to do some portion of the work for which they have been accustomed to rely on the Artillery.

It is precisely in places where such a situation arises that a working scheme between the Artillery and the machine guns and trench mortars will enable a division of labor to be arranged, in which by taking on definite tasks, such as the neutralization of certain areas, the machine gun will be able to do some of the Artillery work, and thereby enable the Artillery to concentrate more guns for other and perhaps more important purposes.

3. The more open the fighting, the more effective is the machine gun; and if (to take an extreme case) the Artillery were entirely eliminated, the machine gun would dominate the situation. For,

(a) The Artillery is the principle protection of the Infantry against enemy machine guns. While the enemy are in occupation of a highly organized defensive area, which has been under close

observation for a long period, it is easier to determine the positions of the enemy machine guns, and therefore easier for the Artillery to destroy them or at any rate neutralize their fire.

(b) But under more open conditions of fighting, it will be much harder for the Artillery to locate and deal with them. Furthermore, whenever the enemy resistance is stout, the Infantry advance must be preceded and covered by some form of barrage fire. Open warfare implies movement. The machine gun is more mobile than the field gun, and it is the only arm outside the Artillery which is capable of covering an attack by long-range overhead fire.

4. Great care must be taken to ensure that in the confusing circumstances of a considerable forward movement, the fire power of the machine guns is not misapplied or wasted. Machine guns at once lose the greater part of their value, if they are hurried forward from their limbers, with inadequate supplies of ammunition, into positions where their fire is masked by Lewis guns and Infantry outposts. The comparative mobility of the machine guns does not mean that the teams on foot can keep pace with a battalion marching in light order. Nor should the fact that the machine guns will in more open warfare have greater opportunities of supporting the Infantry with direct fire, entail the discarding or disturbance of the organization under which the scope for indirect fire has been so greatly enlarged. Experience has already proved that where the conditions approximate those of open warfare, a combination of direct and indirect fire is the best both in attack and defense. The definite attachment of machine guns to Infantry battalions (see Section 4, Paragraph 2) generally defeats its own end. Machine guns, if they are kept well in hand, are at once an instrument of offense and a reserve of fire power within reach of the Infantry commander, but if they are involved in the details of a battalion's movements, they are more likely to be impedimenta than active aids.

5. The situation which has to be foreseen is one in which little or no Artillery is for the moment available. Machine guns will be called upon, and, if properly handled, should be able to assist in making good the shortage of Artillery. Apart from their obvious value for thickening a barrage which is bound to be, at the best, a thin one, the effective use of machine guns for neutralizing strong points, nests of machine guns, and even the field battery positions of the enemy—tasks which in the conditions of warfare hitherto prevailing have been relegated almost entirely to the Artillery—may make the whole difference between the success or failure of operations in which the available Artillery support is necessarily limited.

6. This, however, presupposes:

(a) A high standard of training and ability on the part of the machine gunner.

(b) The allotment of suitable tasks in advance and precise arrangements to that end.

(c) The closest liaison with the Artillery.

Liaison with the Artillery in trench warfare, and in the preparation for and execution of set-piece offensives, is the best guarantee that these desiderata will be forthcoming later on.

33. General Principles.

1. The general principles for the employment of machine guns are the same whether the warfare be that of highly organized defenses, or warfare of a more open nature. While the enemy is himself on the move, the fire power of machine guns must be used to

endeavor to prevent him "settling down;" but once he has taken up a defensive position, a "set-piece" attack has usually to be organized, and then, however small the attack may be, the work of the available machine guns must be prepared in exactly the same manner as has already been described.

2. However fluid the warfare may become, the organization of the machine guns still falls naturally into two categories:

(a) The guns pushed forward to support closely the Infantry and corresponding to the mobile guns whose duties, etc., have already been described in Sections 4 and 36.

(b) The guns retained in the hand of the commander of the force for special covering fire, either direct or indirect, and corresponding to the barrage guns. (See Sections 5 and 36.)

3. The more open the warfare becomes, the more varied will be the conditions under which the machine guns will be employed. For this reason it is impossible to lay down definitely the exact role of each category of guns. In the succeeding paragraphs the work of all the machine guns will be dealt with generally; and it is considered that the details already given are a sufficient guide to the correct methods of organizing and employing machine guns under any tactical condition that may be encountered.

34. Reconnaissance and Appreciation of the Tactical Situation.

1. An accurate knowledge of the enemy's method of defense is desirable, inasmuch as the enemy is himself expert in machine-gun defense, and takes the weight of our assault on a zone of defenses cunningly studded with machine guns. Moreover, as territory is gradually wrested from him, it becomes necessary to incorporate into our own defended system ground that has already been put in a state of defense by him. Machine-gun officers should therefore study carefully the intelligence summaries and special publications in which the information on this subject, obtained from prisoners and captured orders, is reproduced.

2. This general knowledge must be supplemented by exact reconnaissance on the ground itself. A study of the map and through glasses, of the ground, in combination with the map, must precede and follow the actual visit to the ground. This will make the reconnaissance what it should be—the recognition of a situation already envisaged in the rough. The picture thus obtained should be checked, when occasions offer, by aerial photographs, and the map kept up-to-date by the insertion of new details extracted from the intelligence summaries. None of these aids, however, should be allowed to interfere with the examination of the actual ground. For in the isolated operations of more open warfare, machine-gun officers will have to collect for themselves much of the information that is supplied by the general staffs of armies on the eve of a set-piece offensive.

Only thus will it be possible to select in advance suitable localities for the guns, and to detect places from which trouble is likely to occur.

3. The approach to positions must be conducted on the same principle as the forward movement of the mobile guns in a set-piece offensive:

(a) The guns will keep in sub-sections of two guns at least.

(b) From the moment of leaving limbers they will advance by bounds.

(c) The line of advance for the guns and their halting place at each "bound" will be laid down.

(d) A reconnoitering officer, covered by his scouts, will go

forward to reconnoiter routes, and will order up the guns to selected localities, from which they can best assist the Infantry when their assistance is called for.

(e) After the forward representative has selected the site for the guns, and sent or signalled back to them, he will make arrangements to enable them to come into action as soon after their arrival as possible; he will select targets, take ranges, and make any necessary calculations. He should therefore be accompanied by his range-taker.

4. When after a period of movement the situation again threatens to become stationary, every officer should make a minute reconnaissance of the area round his guns, with a view to laying the foundation of a sound scheme of defense. Too often guns are found in places which were originally intended as halting places only, or in places to which they forced in the exigencies of an action, to the neglect of better sites in the vicinity.

If sub-section and section officers, after local reconnaissance, send in sketches showing alternative positions and their fields of fire on tracing paper of the same scale as the map in use, the commanding officers of companies and the divisional machine-gun officer will have at all times the raw materials of a good defensive scheme.

5. In regions where the enemy makes a voluntary retirement to conform with a retirement imposed on him elsewhere, we shall have to pass through, and perhaps remain on, a network of undestroyed fortifications. The machine guns will have to be placed either in these fortifications or in the vacant ground between them. Under these circumstances the following considerations must be weighed:

(a) An old strong point may only have been a strong point because it contained guns and faced a certain way. It will be known to the enemy, and if it possesses no natural strength, it should be avoided.

(b) In winter especially, it will be of convenience to select positions near to existing dugouts which are water-proof and perhaps shell-proof. The fact that prepared defenses need a minimum of new work is pro tanto an argument in their favor.

6. In organized defenses the task of silencing enemy machine guns belongs primarily to the Artillery, but among improvised defenses machine guns will be capable of this. Lewis guns, owing to their greater mobility, will be more successful in stalking single machine guns at close quarters, but machine guns should be effective in silencing, by concentrated fire, active enemy nests.

7. In warfare of an open nature there will be full scope for the bold handling of machine guns, but boldness does not mean unnecessary exposure to Artillery fire or snipers.

8. Machine guns will in most cases be sufficiently protected by the dispositions of the troops with whom they are acting. Where the machine-gun commander finds himself in an exposed position, he should, if necessary, apply to the nearest Infantry commander for a suitable escort. All machine gunners are trained to throw bombs and they should be provided with a small stock of these for use in an emergency.

9. The situation will sometimes arise in which the simultaneous delivery of two or more loosely connected attacks results in exposing the inner flanks of the attacking forces. Should an attack develop against a line of defended localities, it may happen that neighboring troops are drawn apart towards the several centers of

resistance, thus creating a gap through which the enemy can issue to deliver a counter-attack on their flanks.

A machine-gun battery, placed, so as to command the ground on which their counter-attack is likely to come, will be able owing to the great fire power which it can instantly develop, to nip in the bud any such enterprise on the part of the enemy. The method of controlling the fire of machine-gun batteries, described in PART II. of this publication, enables their fire to be directed rapidly on to a new target or threatened area.

10. Attacks on Villages, Woods, and Other Defended Localities.

1. (a) Attacks against towns, industrial regions and large wooded areas, as they necessarily take the form of a set-piece operation on a large scale, cannot be considered to fall within warfare of improvised defenses. The machine guns in such an operation would be employed on the principles laid down for warfare on highly organized defenses. (See in particular Section 35.)

(b) The situation under consideration in this section is that of an army retiring on a wide front and using the village and woods that lie on its path as rear-guard positions from which to arrest temporarily the progress of the pursuing forces. The object of the pursuer, under these circumstances, will be to expel the enemy from his defended localities with as little delay as possible, and drive his rear-guards back on his main force, before that force has had time to "settle down" in a prepared system or to organize new defenses of an elaborate nature.

2. (a) Whenever these defended localities are sufficiently adjacent to each other, they will undoubtedly be organized for mutual support by the long-range fire of Artillery and machine guns.

(b) An operation against such a line will therefore take this form, either of a simultaneous attack against the line on a wide front, or of containing attacks on certain localities in combination with attacks on other localities, the capture of which will make it possible to envelop the enemy on either flank and cut off the retreat of his garrisons.

An operation of this latter nature will at the same time probably allow a portion of the force which has broken through to push on rapidly, and disorganize the retirement of the enemy's main body.

3. (a) As a rule envelopment will be the preferable method; and the enveloping movements of the infantry will be covered by the fire of machine guns from the front and flanks of the locality which is being surrounded. For this purpose a large number of the available guns will be employed with advantage for long-range barrage and searching fire, either direct or indirect.

(b) As the enveloping movements of the Infantry progress, machine guns will be moved to suitable positions on the flanks of the locality, whence enfilade and oblique fire can be brought against the flanks and rear of the defenses.

(c) Long-range fire from machine guns can also be used to barrage the exits from the locality, thus preventing reinforcements, and barring the lines of retreat to the defenders.

Fire of this kind will lower the morale of the defenders, by producing that feeling of insecurity which always arises from a knowledge that the lines of retirement are under the fire of the attackers.

(d) In the case of villages—doors, windows, roofs, backs of houses, streets, especially those running at right angles to the attack, should be subjected to the searching fire of machine guns.

(e) When the Infantry have made good the edge, or some portion of the locality, some of the forward machine guns may be brought up for the closer support of the Infantry.

At the same time the fire power of these guns must not be wasted by placing them in positions where they are liable to be masked by our own troops, or in which Lewis guns, owing to their portability, can do equal, if not better work.

The general rule will be that Lewis guns are used in the more advanced positions and the machine guns kept in positions further back, where their fire power can be best used for the Infantry's support.

41. Defense of Woods, Villages, and Other Defended Localities.

1. (a) Isolated clumps are always to be avoided as they invite concentrated Artillery fire, but clusters of woods, and woods of medium size, even though they are not part of a highly organized system, offer natural advantages for hiding machine guns. It is a long time before the trees are reduced to leafless sticks which afford no cover from view. Furthermore, tree stumps and underground growth are ideal objects in which to fasten and hide wire.

(b) As, however, woods will always be subjected to more or less heavy shelling, the minimum of men should be retained to garrison them. This entails the scheme being laid out chiefly with a view to defense by machine and Lewis guns, covered by forward posts of riflemen and grenadiers. Through the smallness of their numbers the defenders will have plenty of elbow room, and thus be able to shift their positions and avoid those parts of the wood which are subjected to the heaviest shelling.

(c) In basing the scheme of defense on the fire of machine and Lewis guns, it must not be forgotten that while these weapons can deal with any attack which is above ground and visible they are extremely vulnerable to attacks by small parties who, advancing unseen by covered approaches, filter into the position, and snipe or bomb the gunners at close range. In the day time the defense can safely be left to the machine and Lewis guns, protected by a few posts of riflemen and bombers, but at night, when infiltration is most likely to be attempted, the edges of the wood must be strongly held by the Infantry.

2. Villages.

(a) The crowding of machine guns in villages that have not been carefully organized for defense by the construction of deep dugouts, fortified cellars, and the like, only results in heavy loss of guns and personnel.

(b) Positions will be sought, both in and out of the locality, from which all approaches to the village can be covered with belts of cross-fire.

(c) As envelopment is the most probable form of attack, machine guns must be posted to avoid this. Guns placed behind houses or hillocks in the outskirts of a village will often be found useful for this purpose.

(d) The use of houses or enclosures immediately in front of the village, which will give the enemy a commanding view of the village defenses, must be denied to him.

(e) When machine guns are placed inside the village, great use can be made of a strong building as a protection against Artillery, the machine gun being sited behind the building and fired to a flank.

42. Occupation of Various Positions.

1. Machine guns may be hidden in almost any position, but it

is unwise to choose places which are either obvious or easy to recognize, such as crossroads or single objects. Guns should merge into the surroundings, and straight edges or distinct shadows should be avoided. When a position has been camouflaged, the success of the work will be best determined by reports from our own airmen.

2. Banks of rivers, canals, railways, ditches, folds in the ground, hedges, palings and walls, may be used either as gun positions or as a covered avenue of approach.

3. Machine guns in crops are hard to spot from the same level, but unless the camouflage can be made to resemble the crops, the position will be easily picked out by enemy aircraft. A field covered with manure heaps or mounds of roots makes a better background.

4. If a barricade has been constructed across a road, machine guns should not be put on the barricades itself, but in a concealed position to a flank from which they can enfilade the road.

5. Hay stacks and trees are more suitable for observation posts than for emplacements; but in the same way as buildings in villages, they can be used to defilade machine guns which are located behind them and fire to either flank.

43. Advance Guards. (See F. S. R. and I. D. R.)

1. The duties of an advance guard make it necessary that great fire power should be available when required. A large proportion of machine guns should therefore be allotted to advance guards.

2. These machine guns should be well forward in the column, so that they may be able to get quickly into action.

3. The principle duties of machine guns with the advanced guards are:

(i) To assist in driving back enemy forces by rapid production of great fire power at any required point.

(ii) To assist in holding any position gained until the arrival of the Infantry reinforcements.

(iii) To cover the deployment of the main body by holding the enemy on a wide front.

The reconnoitering officer (See Section 39, Paragraph 3) must consider the following:

(i) How can machine guns assist in covering the advance of the Infantry.

(ii) What is the best way to employ machine guns to secure any ground won.

(iii) Can machine guns cover the reorganization of the Infantry if the attack does not proceed.

(iv) How can the flanks be protected.

(v) Places likely to give trouble.

(vi) How can the machine guns deal with them.

4. Normally, Lewis guns will be employed with a vanguard, and machine guns with the main guard.

With large forces, however, it will often be of advantage to employ some machine guns with the vanguard. For example, with an advance guard of an Infantry brigade, which has one battalion acting as vanguard, a normal distribution will be one section with the vanguard and three sections with the main guard.

5. The section acting with the vanguard will be the forward guns mentioned in Section 38, Paragraph 2 (a) and in the case of an attack being developed by the advance guard, their role will be similar to that of the mobile guns, as mentioned in Section 4. The three sections with the main guard will be those mentioned in Section 38, Paragraph 2 (b), and in case of an attack being developed by the advance guard their role will be similar to that of the barrage guns, as described in Section 5.

Whether their fire is direct or indirect, or whether a portion of them use direct fire and a portion indirect, will depend on the tactical circumstances of the particular situation, the nature of the ground, the amount of artillery at the disposal of the enemy, etc.

44. Rear Guards. (See F. S. R. and I. D. R.)

1. As a rear guard will usually be required to hold positions with the minimum of men, a large proportion of machine guns should be allotted to them.

2. Experience of war shows that well placed machine guns supported by a few Infantry only, will frequently hold up an advance for long periods.

3. The method usually adopted by the enemy is to leave behind numerous machine guns, escorted by small parties of Infantry. These detachments occupy lines of defended localities in which, according to their orders, they hold out to the last, or up to a certain hour on a particular day.

4. In occupying a rear guard position with machine guns, the same principles apply as for the defense in warfare of highly organized defenses, the only difference being that if the defenses are of an improvised nature, the concealment of the guns will be of paramount importance.

5. The organization of the guns falls, as before, into two categories:

(a) The forward guns, whose duties are generally those described in Section 21.

(b) The barrage guns. These guns, using either direct or indirect fire according to the circumstances, will be used to search with long-range fire good approaches for hostile troops, and also to cover by barrage fire the withdrawal of the forward guns when this is necessary.

6. If it is required to fall back by stages, a portion of the barrage guns, after having covered the withdrawal of the forward guns, can themselves become forward guns, the forward guns taking up the work of the barrage guns at some point further in rear.

In this way a continuous resistance will be offered to the hostile advance.

7. In addition to the ordinary principles of defense the following points will be specially observed:

(a) The field of fire will be wide, and engage the enemy at long range.

(b) Machine guns will be concealed in the least obvious places.

(c) Covered lines of retirement will be reconnoitered.

(d) Limbered wagons will be close up to facilitate withdrawal when the time for this comes.

Pack transport will be found useful for the withdrawal of forward guns.

(e) Positions in rear will be chosen before the machine guns retire from their forward positions, and carefully reconnoitered.

(f) A proportion of the machine guns will occupy the positions in rear, to cover the retirement of the forward guns. (See Paragraphs 5 and 6). Thus the retirement of the last gun can be covered.

8. A study of the foregoing considerations will enable Infantry commanders to appreciate the nature of the resistance which they may expect to meet from enemy machine guns fighting a rear-guard action in the open; and also will enable machine-gun commanders to deal skillfully with a situation in which a local retirement is temporarily imposed in the course of a general advance.

PART III—SECTION 2.

MACHINE GUN RECONNAISSANCE.

1. General Considerations.

Definition. The service of obtaining information with regard to the topographical features of a country and the disposition and movements of an enemy.

Time. Even when armies are at their swiftest there is ample time for reconnaissance as a rule. As a general thing at least 12 hours before a set piece can be reckoned on.

Reconnaissance is the only guard against surprise. To be surprised is unpardonable in military service.

Object. To obtain information.

Means. A. Air service. B. Personal observation. C. Patrols.

A. Results of air reconnaissance are given by aero photos and verbal reports of contact patrols. Aero photos are uncertain guides to hill features as they show presence of a slope but nothing else.

As a guide to ground they are detailed. They may assist to give route for guns to go forward, especially oblique photos. They convey the latest information as to enemies movements, especially tracks, and they must be studied in conjunction with the map. Targets for harassing fire can be best chosen from aero photos.

B. **Personal Reconnaissance.**

1. Use of map. 2. Examination of ground. 3. By going over ground. 1. Use of maps merely an aid to get a comprehensive view of places. Difference of scales must be remembered and distance adjusted. Use of mould of ground features.

The general features govern the main idea, but the minor features govern the special idea. When studying maps for barrage fire remember that barrages do not depend on field of fire but on clearance.

Officers going forward must adapt his general orders to his personal reconnaissance.

2. **Examination of Ground.** (From a point of vantage.)

This saves time, give a comprehensive view of ground and enables plan of attack to be drawn up quickly. The officer goes up to the nearest high point of course. From there determines what the enemy wants and how he may get it. Determines how to prevent it and then allots the defense to the troops.

Artillery O. P. will yield valuable information.

If attack is contemplated you can study the best means of approach to enemy's main defence, lines of advance of guns, communication and supply.

3. **By Going Over the Ground:** Machine gunner's reconnaissance gives them the actual places for guns. Points for covering fire can be indicated. In position—warfare personal reconnaissance is of the greatest importance. It is of great advantage if second

barrage positions are visible from one's own lines. When guns are going forward officer reconnoiters in front of his guns, with signallers to identify positions guns are to take up. The signallers go back and bring guns up.

C. Patrols.

Patrols are sent out to ascertain the possibility of some route. Machine gun scouts are not sufficiently trained in this work and do not give either accurate or useful information. (For Scout Training see F. S. R. and I. D. R.)

Not enough attention is given to this subject in machine gun companies. Give series of points which scouts should be posted.

Rules for Scout Reports, Precision.

Avoidance of set terms as regards time "about" or "apparently," "behind a village," hours 12, should be followed by "noon" or "midnight." Names of places and persons in Block Capitals. All map bearings must be grid bearings.

To whom (Message.) Message No.

Time Signature
Date Rank
Sender

Means by which sent

Place from which sent

Report should be divided into paragraphs, each numbered and a plan added if possible. It is often practicable to have a plan made out beforehand and the scout fills in details as he goes on.

The message form shown below has been found of great value in recent fighting, with the British Machine Gun Corps on the Western Front.

Message No.....

To C. O.....M. G. Company.

1. I am at.....
2. I need ammunition.
I need water.
I need Very lights.
I need spare parts.
3. Counter-attack forming at.....
4. I am in touch with.....on right
I am in touch with.....on left
5. I am not in touch on right.
I am not in touch on left.
6. No troops are in front of me at.....
by own Artillery
7. I am shelled from.....
enemy
8. Hostile Battery active at.....
Hostile Machine Gun active at.....
Hostile Trench Mortar active at.....

(Space for messages.)

Time.....Name and Rank.....
Date.....No.....Platoon
Map Reference.....M. G. Company.....

3. Reconnaissance for the Attack.

General points to be considered:

- a. The object in view.
- b. Factors likely to affect the situation.
 - (i) Topographical.
 - (ii) Relative numbers.
 - (iii) Probable object of enemy.
 - (iv) Weather conditions.
 - (v) Ammunition.
 - (vi) Supplies.
- c. Courses open to own troops.
- d. Courses open to enemy.
- e. Proposed action.

Detailed points to be considered.

- a. Dead space.
- b. Field of view from prone position.
- c. How much ground is commanded from enemy position?
- d. Selection of gun positions having best command and least exposure.
- e. Suitable lines of advance communication and withdrawal.

4. Reconnaissance in the Defense.

1. Points to be considered.
 - a. Note our particular sector and obtain the most up-to-date map, and disposition of Infantry with whom working.
 - b. Note doubtful points not brought out on sketch or map.
 - c. Intelligence summaries.
2. Enemy line.
 - a. Distance from our own front line and general position.
 - b. Known and probable hostile machine-gun positions.
 - c. Danger points.
 - d. Ground behind enemy's position.
3. Position of forward guns.
4. Main line of defense.
5. Position of reserve guns.
6. State of repair of positions.
7. Routine in force.
8. Enemy practice.
9. General scheme of defense.

PART III, SECT 3....

ORDERS.

(Study F. S. R.—Art. 3.)

1. The art of giving proper instructions and orders to troops is one of the most important features in the exercise of command.
2. Orders to machine gun units are usually written. In trench warfare especially, orders must be written as units are dispersed over large areas.
3. Always read an order three times and analyze it.
4. For types of orders and forms: General—Special—"Orders"—see F. S. R.
5. The object of a field order is to bring about a course of action in accordance with the plan of the commander, suited to the situation and with full co-operation between all arms and units.

6. Before writing a field order it is necessary to estimate the situation, following a logical scheme or reasoning.

7. Orders in General.

Estimate of the situation.

Missions. 1. What special thing are you to do?

2. What does your superior expect of you?

Enemy. 1. His location—formation with respect to the situation.

2. Strength and arms.

3. Probable intentions.

4. Morale.

Our Troops. 1. Strength and arms.

2. Location.

3. Morale.

4. Efficiency.

5. Condition of troops.

Terrain. 1. Configuration of ground.

2. Roads, streams, woods, villages.

(With respect to your intentions.)

Time and Distance. 1. Time required.

2. Distance in cover.

Plans—The different means of accomplishing your mission.

Decision—Decide on one plan and do not deviate from it.

Having weighed everything—all conditions and circumstances (quickly) with respect to your mission—proceed to write the necessary orders. In general, there are two forms of orders:

1. Giving minute details.

2. Giving necessary details in the form of tasks, leaving the exact method to the judgment of those charged with execution of the order.

The first form is to be avoided as you cannot foresee all contingencies—and should be resorted to only when subordinates are not well trained in their duties. Commanders should always assume full responsibility—therefore, an order should contain:

1. No apologies or guesses.

2. No provisions for events which may never occur.

3. No ambiguous words and modifying expressions: "As well as you can;" "As far as possible."

Important requisites:

1. Clear, concise, complete.

2. Legible writing.

SPECIMEN, FIELD ORDER—AMERICAN.

Secret.

Copy No.....

Hqs. 25 M. G. Co.,

29 March, 1918, 4:00 P. M.

Co. Field Orders No. 1.

May Reference.

(1) Information of the enemy—has he attacked recently or is he preparing for it; Companies on right and left; brigade occupying the sector.

(2) This Co. will relieve the 24th Co., in the Grant sector on the night of March 30-31, 1918.

(3) The relief will proceed as follows:

(a) The first platoon will relieve the first platoon of the 25th Company in Berry Trench.

Guns disposed as follows: (Map Ref.) Plat. Hqs. will be at —(Map Ref.)

(b) The second platoon will relieve the second platoon of the 25th Co. in Down Trench.

Guns disposed as follows (Map Ref.) Plat. Hqs. will be at (Map Ref.)

(c) The third platoon will relieve the third platoon of the 24th Co. in Easy Trench: Gun positions as follows: (Map Ref.); Plat. Hqs. will be at: (Map Ref.)

(x) The company fully equipped will be formed March 30, at 7:30 p. m., with carts packed and rations for the gun squads for the next day.

The company will march at 8:00 p. m. the same night by platoons in the order first, second, third, maintaining a distance of 200 yards between platoons. Carts will follow in rear of their respective platoons.

Carts will halt in succession and be unpacked at the trail crossing Buf Creek at: (Map Ref.)

Movements from the carts will be by gun squads, suitable distance being maintained by each squad.

Guide from the 24th M. G. Co. will meet the relief at Buf Creek Crossing and will pilot them to advance company headquarters.

Trench stores will be carefully checked and receipts given.

Firing program will be taken over and continued—Programs of work will be carried on.

"Relief complete" will be reported to advance company headquarters by the most direct means in code.

4. Advance company headquarters will be: (Map Ref.). Rear Co. Hqs. will remain at this point—I will march at the head of the first platoon.

Signed,

How issued.

Acknowledge receipt.

Copies to—

Field orders are absolutely SECRET. Name of places, roads, streams printed in Roman Capitals.

Write out—NOON and MIDNIGHT.

Night is expressed "Night—4/5 March."

PART III, SECTION 4

THE ORGANIZATION OF MACHINE GUNS WITHIN A DIVISION FOR ATTACK AND DEFENSE.

Many text books and pamphlets, including copies of British and French manuals have been published by the War Department on Machine Gun tactics. Of these, Training Circular No. 2, "Notes on the Employment of Machine Guns," (issued on November 7th, 1917), appears to be the most complete and in accordance with the present tactical use of machine guns on the Western Front. But in none of these publications have the functions of the two types of the machine gun organization within a Division been considered. In other words, the employment of the M. G. battalions and the M. G. companies respectively in defense and attack, has not been clearly dealt with.

It is the aim of these notes to discuss this subject in detail; and in doing so reference will be made throughout to Training Circular No. 2, copies of which have been issued by the War Department to all divisions and departments.

The functions of the Divisional Machine Gun Officer, are discussed, while the whole question of communication and liaison in both attack and defense between the machine guns, and all arms of the service operating with them is dealt within detail.

The machine gun units in a division fall into two groups: (a) The machine gun companies of the infantry regiments. These are an integral part of the regimental organization, and under the direct command of the Colonel commanding that unit. (b) The machine gun battalions. These are independent units, and in the case of the two brigade Bns., take their orders from brigade commanders. The divisional machine gun Bn. is directly under the orders of, and responsible to General Staff of the division.

The part each of these organizations is to play in the general M. G. scheme for the division sector must be considered, for it must always be clearly understood that a general scheme for the co-ordination of all M. Gs. will have to exist. Tactically the guns fall into two main divisions:

- (a) **In Defense.** (i.) The Forward Guns.
(ii.) The Barrage Guns.
- (b) **In Attack.** (i.) The Mobile Guns.
(ii.) The Barrage Guns.

It is to be remembered that after an attack our Mobile guns become Forward guns, and vice versa. (See Part III., Section 1, Sub-Section 36, Paragraph 6.)

It is essential that in allotting tasks to the M. G. units, particular attention be paid to the regimental and battalion organization. This can best be illustrated by the attached plan, in which it will be seen that the regimental M.G. companies provide the Forward or Barrage guns, and the M. G. Bns. the Barrage guns.

This suggestion is based upon the following assumptions and the adaption of the principles laid down in Training Circular No. 2.

THE DEFENSE.

The division will be distributed on a two brigade front, each with one regiment in the line and the other in brigade reserve.

(a) **THE FORWARD GUNS.** The Regimental Headquarters of the regiment in the line will be somewhere back of the front line system in rear of the intermediate line. At or quite close to this H. Q. will be the headquarters of the M. G. commander of that regiment, for naturally as a regimental staff officer, the C. O. M. G. commander should be near his colonel. The establishment of the M. G. Co. is three (3) platoons, each of four (4) guns. The regiment is organized into three (3) Bns., and would be distributed in depth; probably one Bn. in each sub-sector with the remaining Bn. in regimental reserve. The twelve (12) guns of the M. G. Co. should be quite sufficient to provide the Forward guns in the sector, and these will be distributed on or around the support line. Their double functions are described in Training Circular No. 2, Section 21, Paragraph 3. Now the platoon commander of these Forward gun platoons should be at or quite close to the H. Q. of the Bn. in whose area he is operating; in other words, where there is a Bn. H. Q., there will also be a M. G. platoon H. Q. By this means the whole question of communication and liaison is simplified; the M. G. officer is in communication the whole time with the Infantry Bn. commander, and can get through on the latter's telephone lines or by visual signaling direct to his Company commander at regimental H. Q.

The regimental M. G. Co. stays in the line as long as does the regiment, and its place is taken by the M. G. Co. of the relieving regiment.

(b) **THE BARRAGE GUNS.** In accordance with Part III., Section 1, our barrage batteries will be somewhere in immediate rear of the intermediate line or "line of posts;" and their functions are laid down in Section 23, Paragraph 2. These batteries will be provided by the brigade M. G. battalions, and the Bn. commander will be the group commander of the barrage batteries in that sector. Each company in the Bn. would provide one battery of one or two platoons, with the remaining platoon in Co. reserve to permit of reliefs within the battery; for the M. G. Bn. would stay in the line as long as the infantry brigade to which it is attached.

The group or Bn. commander would have his H. Q. at or near brigade H. Q., and thus would be in communication either directly or through brigade with regimental H. Q. and the M. G. commander of the Forward guns.

By this means it will be seen that units maintain their organizations intact and M. G. unit commanders are in direct touch, not only with each other but with their immediate superiors to whom they are responsible.

Through his brigade H. Q. the group commander is in communication with the divisional M. G. officer at division H. Q.

The division M. G. battalion has now to be considered. What is its part in the M. G. organization? It is important to remember in this respect that the division M. G. Bn. is a mobile reserve of fire power in the hands of the division commander, which it is essential to keep under a centralized control at division H. Q. as long as possible. The place of the commander of that unit is therefore at division H. Q., where he is in direct touch with the general staff. The guns of his Bn. could be used to reinforce any portion of the divisional sector, but it is recommended that Forward guns should not be strengthened by this means; such a duty, if necessary, being performed by a platoon or more of the M. G. Co. of the regiment in brigade reserve. This fits in more with the training and organization of the regimental M. G. units. But a battery might be detached from the division M. G. Bn. and attached to each or either barrage group, in particular in preparing for an attack when large schemes for harassing fire are being carried out. In such a case gun batteries so detached would take their orders direct from groups to which attached, and not from their own Bn. commander.

Apart from this the guns of the division M. G. Bn. would be employed on anti-aircraft defenses, both for the barrage batteries and for the division artillery, on the preparation of emplacements in the corps line, and in a general way as division reserve.

THE DIVISIONAL M. G. OFFICER.

His duties are to co-ordinate the work of the machine guns, Forward and Barrage, throughout the division, arrange for the mutual support of flank divisions, and insure that there is a complete co-operation between neighboring regimental M. G. Co.'s, and a proper division of labor between the left and right barrage groups. It can be seen at a glance that the division M. G. officer is in direct communication through brigades with left and right barrage groups and the regimental M. G. Co.s providing the Forward guns.

COMMUNICATIONS.

The method of communication has been outlined, and it will be seen that it fits in with the infantry scheme. The group commander will be in direct telephonic communication with his bat-

teries, and also with the observation post, the latter being especially necessary for the employment of the "Sniping Battery." (See Part III., Section 1, Sub-Section 31.)

The group commander therefore will be in touch by telephone with (i.) Brigade H. Q.

(ii.) H. Q. C. O. Forward Guns.

(iii.) Division M. G. Officer.

(iv.) The Group Observation Post.

(v.) Each Battery.

LIAISON.

(i.) The platoon commander of the Forward guns in a Bn. area is naturally in direct communication with the Bn. commander, and his intelligence officer, and he would attend the Bn. commander's conferences daily. As both infantry and machine gun officers usually make their tours of inspection to receive reports during the morning, it is recommended that there should be a meeting of all concerned in the defense of the brigade sector at regimental H. Q. some time in the early afternoon, 2 o'clock, for instance. The following officers should attend:

(a) The Regimental Intelligence Officer. He will, by this time, have received reports from Bn. I. O.s in the line, and have all data to hand.

(b) The Field Artillery Observation Officers, light and heavy artillery. These officers will bring with them lists of targets fired upon by the gunners during the last twenty-four hours.

(c) Trench Mortar Officers, who will have similar information.

(d) M. G. Co. Commander of Forward guns.

(e) Representative, Adjutant or I. O. of barrage group.

By this means all interested in the defense of the sector can meet and confer. The M. G. officers can then at once decide upon targets to be fired on for the night's harassing fire program, and all arms be cognisant of them. Also there is time for both officers commanding Forward and Barrage guns to allot targets and allow time for calculations to be worked out.

The barrage group commander having arranged his program, then passes to brigade H. Q. for approval, and notifies Division M. G. officer.

(ii.) But the division M. G. officer is in communication with the artillery brigade commander's staff at division H. Q., and thus may have arranged for the co-operation of the M. G. of the division in some joint harassing program, or he may have some special targets to allot. In any case either of such orders would have to be issued by him through general staff to left and right barrage groups (through respective brigade H. Qs.) before 5 o'clock, to insure that all preparations necessary could be made in time.

By this means it will be seen that not only the offensive spirit of machine guns is maintained, but there is no delay in dealing with the "points sensibles" in the enemy's defenses, and if the system is maintained he is reduced to a state of weakness and demoralization ready for a general attack.

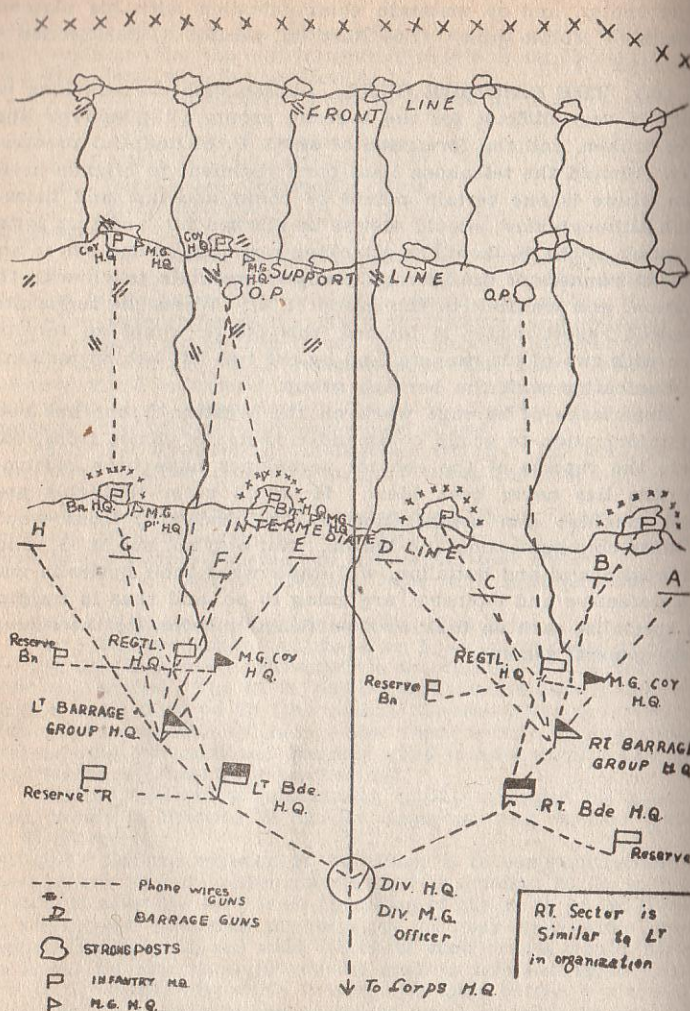
THE ATTACK.

(i.) **THE MOBILE GUNS.** These are supplied by the M. G. Co. of the attacking regiment, supplemented, if need be, by the guns of the regiment in reserve. Again the system of the M. G. officers having their H. Q. or "report centers" with the infantry H. Q., must be adhered to. The M. G. Co. commander will form his advanced H. Q. or "report center" at the regimental advanced

report center, and so maintain communication with his platoons or pairs of Mobile guns. (See Part III, Section 1, Sub-Section 4, Paragraph 1.)

(ii.) **THE BARRAGE GUNS.** Liaison with the attacking infantry is very difficult for the barrage group, all telephone lines being broken, and the formation of an O. P. of doubtful practicality. Should the telephone lines from regiment to brigade break down, there is one certain means of communication and liaison, which although slow, should always be allowed for, and that is the stationing at the H. Q. of the attacking regiment of one officer and four (4) runners of the barrage group to maintain touch with the situation, and transmit to the group H. Q. When the regimental advanced report center is formed, this officer would go forward there with two of his runners, and by the two left behind maintain communication with the barrage group.

Experience of barrage work on the Western Front has been that information to group commander normally comes from rear, where the reports of the contact aeroplanes have been received. But this has never been ideal. It would seem that this proposed machine gun organization on the divisional front would facilitate communication and liaison. Not only so, but M. G. units, both regimental and battalion, will know what their duties in war, both defensive and offensive, are going to be, and thus in training can specialize each on their own particular mission for the success of the general scheme.



NOTES ON THE TECHNICAL AND PRACTICAL WORKING OF MACHINE GUN BARRAGE.

1. For the tactical principles and considerations governing the use of the M. G. barrage in attack and defense, see Part III., Section 1. "Tactical Employment of Machine Guns," Sections 5-11, 23-25, 27-31. It is the aim of these notes to aid M. G. officers in the technical and practical side of the work.

2. MACHINE GUN BARRAGE.

The accuracy and success of barrage fire depends to a great extent upon simplicity of organization, control and laying. The methods practiced should, if possible, be equally applicable to: (1) a set piece in which there is ample time for preparation; (2) to the later stages of large operations, when it is necessary for M. Gs. to move forward to new positions from which to put down a barrage and when time is an important factor; (3) and to conditions of open and semi-open warfare, in which M. G. barrage becomes of increasing importance as our own troops get out of range of artillery support. It is important to attain flexibility i. e. to enable the controlling officer to put down a barrage on any line or area without loss of time.

Barrage Fire is ordinary indirect fire organized on a large scale. The methods described in the following pages do not replace the usual methods of carrying out indirect fire, but will assist in attaining speed and accuracy. They must be regarded as a guide and a basis of training, and not as a fixed system. Experience alone can decide for the controlling officer the best methods to adopt, and these will depend on the tactical features, such as time, terrain etc.

3. THE ORGANIZATION of the barrage guns into groups and batteries has been dealt with above. Batteries are lettered from right to left (A, B, C, etc.) along a divisional front. If they move forward they become A2, B2, C2, etc.

Frontage Per Gun. Counter attacks have been stopped by M. G. barrage produced by "Rapid Fire" from M. Gs, each covering forty or fifty yards of the frontage to be barraged. At ranges of 2,400 yards and over the frontage per gun should be reduced to twenty or thirty yards, and at extreme ranges even less. This applies to frontal, oblique and enfilade barrages. As a guide to the intensity of the barrage it may be of interest to know that if guns fire at the rapid rate and take on a front per gun equal in yards to four times the denominator of the gradient of descent at that range, fifty per cent of casualties should result. The influence of the slope of the ground should also be considered in estimating the effect of the barrage.

4. DUTIES OF THE BARRAGE COMMANDERS.

THE DIVISIONAL M. G. OFFICER IS RESPONSIBLE FOR:

- (i.) The carrying out of the orders issued by the Commanding General of the Division.
- (ii.) The organization into groups of the guns allotted to barrage fire.
- (iii.) The issuing of field orders which will include the allotment of tasks to the various groups.
- (iv.) The co-operation of the work of the M. Gs. in the division and the proper division of labor between barrage groups. (See Appendix A.)

THE GROUP COMMANDER IS RESPONSIBLE FOR:

- (i.) The carrying out of divisional orders with regard to M. G. of his group, which orders will be communicated to him in

detail by the divisional M. G. officer.

(ii.) The organization of his group into batteries.

(iii.) All preliminary preparations which include estimates for small arms ammunition S. A. A. water, oil, spare parts, and material required for emplacements, the formation of dumps and arrangements for communications.

(iv.) The issue of field orders, which deal with the tasks and the location of each battery. The tasks will be entered on a chart showing targets, rates of fire, time, etc., and any moves. These charts must be issued to battery commanders in time for them to make their calculations, and to send them to group commanders to be checked. (See Appendix B.)

(v.) The construction of a fighting map, showing the positions, tasks, and zero lines of his batteries (see Appendix C) zero.

REFERENCE OBJECT									
ANGLE OF SWITCH									
N°6	N°7	N°5	N°5	N°4	N°3	N°2	N°1	N°8	N°7
				210R	218R	226R	234R		

THE BATTERY COMMANDER IS RESPONSIBLE FOR:

- (i.) The carrying out of group commanders orders.
- (ii.) The laying of the zero lines of his battery.
- (iii.) The construction of a fighting map for his battery. (See Appendix E.)
- (iv.) The issuing of a gun chart to each gun commander. See Appendix D.)
- (v.) Arranging so that every commander in his battery, including himself, has an understudy.
- (vi.) The supervision of the fire, etc., of his battery.

THE GUN COMMANDER IS RESPONSIBLE THAT:

- (i.) His gun fires according to orders on gun chart.
- (ii.) The gun numbers carry out the detail of the barrage drill.
- (iii.) The correct elevation is put on the gun and maintained.
- (iv.) He receives and acts on the signals or other communications from the battery commander or the officer controlling the fire.
- (v.) When a barrage is ordered which is not entered on the gun chart, the gun is correctly laid before reporting "No.—Gun ready to fire."

5 LAYING.

The method of laying which facilitates control is described under the heading, "Distribution and Concentration." To give quite accurate results this method requires that the guns of the battery shall be at equal intervals. If the guns are not at equal intervals, the error at the target for any gun is equal to the distance that gun actually is from the position it would occupy if the guns were at equal intervals.

In the case of the two flank guns of the battery, there will be no error due to unequal intervals between the guns. Barrage guns are usually arranged in eight gun batteries. Each gun has a zero aiming post. When the gun is laid on its zero aiming post, it is said to be laid on its zero line.

All guns in the same battery have parallel zero lines. Several methods of laying out parallel zero lines are given under Paragraph

4. The zero aiming posts must not be moved, for all calculations for switching or distributing the fire of the guns are worked from the zero lines on which guns relay after each task.

When a battery engages a target, each gun usually takes an equal share of the target. In this case the guns are laid at equal intervals along the target, each gun traversing through an equal angle and to the centers of the traverses of the guns on either side, insuring over-laps (see Figure 1.) When the guns are laid for direction each gun will usually be given a traverse of two degrees or thirty mils. (fifteen mils. left and fifteen mils. right), or twice the angle of distribution per gun, whichever is greater.

(a) DISTRIBUTION.

When a battery on a narrow front engages a target of much wider front than that of the battery, some method of "distributing" the fire equally along the whole target front is needed.

In dealing with distribution of M. G. fire along a target it has to be considered whether it is a frontal or oblique barrage; a barrage is said to be frontal if the angle between the target and the line joining the directing gun to the corresponding end of the target is between 80° and 100° i. e. approximately a right angle. If this angle is less than 80° or greater than 100° the barrage would be said to be oblique. Each of these targets calls for a separate method of calculation.

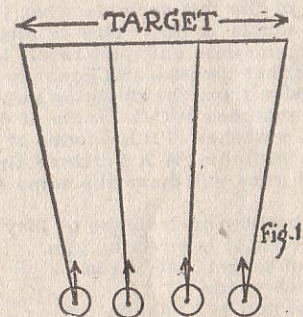
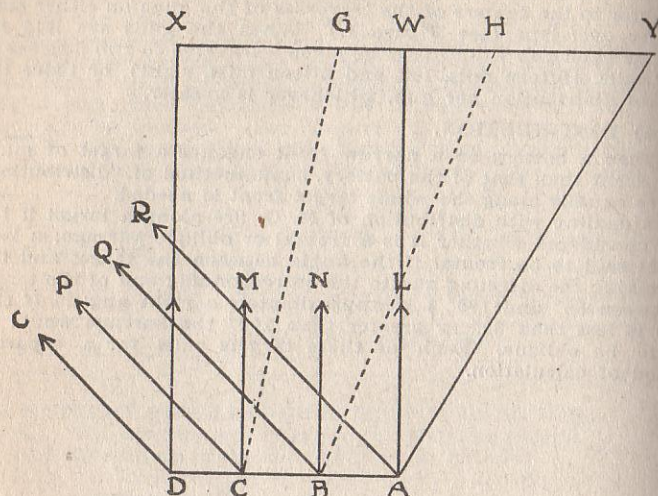


Fig. 1.

(1.) FRONTAL BARRAGE.

Suppose X Y to be our target, and D A the frontage of the battery. D O, C P, B Q, A R, are the guns of the battery on their parallel zero lines. It will be seen that if all the guns swing

through the O D X, they will be brought on parallel lines with D X the directing gun laid on the left end of the target (X D O is the angle of switch). But if the guns fired on these lines they would only cover X W (equals D A), so the fire must be opened along X Y.



Rule. Subtract frontage of battery from frontage of target i. e. W Y find by use of the mil. formula what this length subtends at that range D X (equals A W). This is angle W A Y in mils. divide by number of guns less one, and result is angle of distribution of the battery for that target. The guns lay off this angle right in arithmetic progression from the directing gun i. e.

No. 3 gun switches M C G=angle of distribution.

No. 2 gun switches N B H=twice M C G.

No. 1 gun switches W A Y=three times M C G.

N. B. All guns will have the same Q E.

Example.

Four gun battery on frontage of fifty yards.

Left gun or No. 4 is directing gun.

Frontage of target, 120 yards.

Range, 2,000 yards.

Angle of switch is 210 mils.

Here W Y=70 yards.

$70/2,000 \times 1,000 = 35$.

A of distribution=12 mils. (to nearest mil.)

Fire order is:

All guns 210 mils. right.

Left gun directing.

Distribute 12 mils.

LOAD.

Q. E. (same for each gun).

FIRE (by signal).

For detailed action of No. 1, see "Barrage Drill," (Appendix H).

On the Battery charts (see Appendix B) is entered:

(i.) "Angle of switch" i. e. X D O=210 mils.

(ii.) "Distribution angle" i. e. M C G ($\frac{1}{3}$ W A Y)=12 mils.

And in lower part of the orders and in the barrage charts (see Appendix D) is entered:

(iii.) Angle from zero line for each gun, in this case:

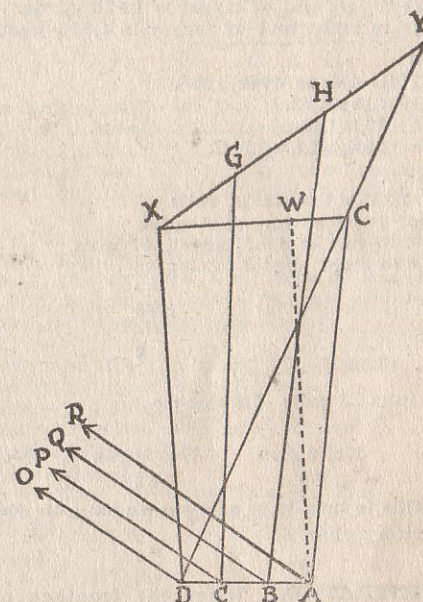
No. 4 gun	No. 3 gun	No. 2 gun	No. 1 gun
210 Rt	210 Rt	210 Rt	210 Rt
	+12 Rt	+24 Rt	+36 Rt
i. e. 210 Rt	222 Rt	234 Rt	246 At

Gun chart for No. 2 gun would merely show under "Gun Angle of Switch" for this target, 234 Rt.

Note. W A Y can be measured off the map; but the calculations involved in the above method are so slight that it does not seem worth while risking inaccuracy of measurement and making mistakes by drawing in the line A W.

(II.) OBLIQUE BARRAGE.

Suppose as before, X Y is our target and D A the frontage of the battery. As before, all the guns will swing through the X D O, which will bring the left gun (directing) on to the left end of the target, Angle Y X D is greater than 100° . It will at once be seen therefore, that the method of distribution used for a frontal barrage cannot be used in this case.



Rule. Draw X C at right angles to X D and cutting Y D at C, then X C is the working base which we shall use for calculating the angle of distribution as for a frontal barrage instead of X Y.

X C can be measured off the map, but here again it necessitates drawing lines on one's map which is not always convenient.

TO CALCULATE LENGTH OF X C. Find number of tens of degrees Y X D is less than 80°, or greater than 100°. Take this number of tenths of X Y. Subtract resultant from X Y and the answer is X C.

QUADRANT ELEVATION.

This is however, the question of Q E'S for the gun to be decided, as they vary of course. Find the Q E to left end of target and to right end of target. Subtract and divide resultant by number of guns less one; then give order as for combined sights. Such difference in the Q E'S can be entered in the space of Gun elevation on the Battery chart, and will of course, be entered for the gun concerned on the Gun charts.

Example.

Four gun battery of 50 yards frontage.
Left gun is directing gun.
Frontage of target=180 yards.
Y X D=137°.
Angle of switch is 178 mls. Rt.
Range to left end of target is 1,825 yards.
Range to right end of target is 1,975 yards.

Then:

137° is 4 tens over 100°.
 $4/10 \times 180 = 72$.
 $180 - 72 = 108$.
 $108 - 50 = 58$ i. e. X C.

Then:

$58/1,825 \times 1,000 = 32$ mls.
A of Distribution = 11 mls.
Q E to left end of target, 47 mls.
Q E to right end of target, 55 mls.

3 | 88
—
3

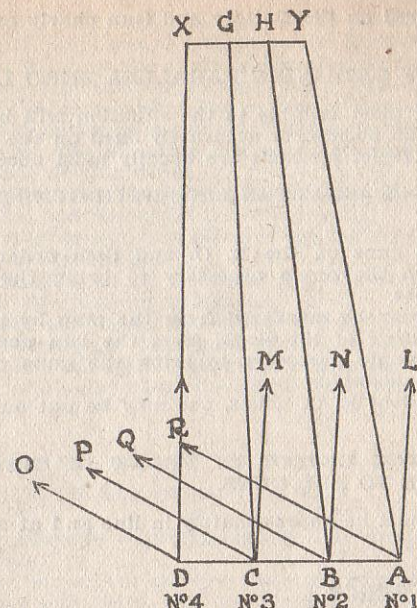
Q Es:

47 mls., 3 mls. differences
or

No. 4 gun	No. 3 gun	No. 2 gun	No. 1 gun
47	50	53	56

And this is how it is entered under gun elevations space on Battery charts.

(b) **CONCENTRATION.** When the frontage of the battery is greater than the frontage of the target, or in other words when X Y—D A gives a minus quantity then the fire of the battery must be concentrated, as before all guns must swing right (or left as the case may be) X D O, the angle of switch. This brings guns on parallel lines with D X on left end of target.



Rule. As before, subtract D A from X Y, find what angle in mls. the resultant subtends at that range D X; divide that angle by number of guns less one and this gives angle of concentration for the battery for that task. As this is concentration, each gun will switch this angle left in arithmetical progression towards the directing gun.

No. 3 gun switches left M C G=angle of concentration.
No. 2 gun switches left N B H=twice M C G.
No. 1 gun switches L A Y=three times M C G.

N.B.—If it is desired to concentrate fire on one point, it will be seen X Y is zero, but the same rule is used.

Example:

Frontage of 4 gun battery is 50 yards.
Frontage to search is 20 yards.
Range is 1,800 yards.
Angle of switch is 95 mls. Rt.
Then applying Rules:

$20 - 50 = -30$.

So we have to concentrate our fire.

$30/1,800 \times 1,000 = 100/6$.

$100/6 = 16.6$.

16.6

— = 6 mls.

3

Angle of concentration=6 mls.

Then if left gun is directing gun:

No. 4 gun switches from its zero line 95 mls.

No. 3 gun switches from its zero line $95 - 6 = 89$ mls.

No. 2 gun switches from its zero line $95 - 12 = 83$ mls.

No. 1 gun switches from its zero line $95 - 18 = 77$ mls.

This is entered on the Battery and Gun charts as for distribution.

6. METHOD OF OBTAINING PARALLEL ZERO LINES.

The method most suitable to the situation will be used. Provided that the gun position is accurately fixed on the map, the distant Reference Object methods are usually most accurate.

(i.) REFERENCE OBJECT IN LINE WITH GUNS AND GUNS IN LINE.

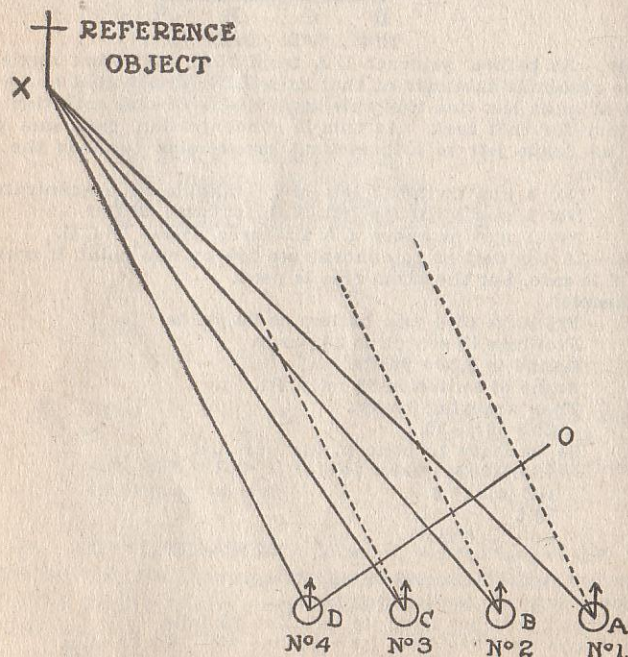
Lay all the guns on the R. O. and then order them to be switched through the angle necessary to bring them on to the required zero lines.

This angle may be measured from the map by protractor; or the compass bearing of the R. O. from the gun position may be taken, and the angle necessary to bring the guns on to the required bearing calculated.

If no convenient R. O. exists, one may be put out and used in this way.

(ii.) REFERENCE OBJECT IN FRONT OF BATTERY AND VISIBLE TO ALL GUNS.

(The guns must be approximately in line and at approximately equal intervals.)



It will be seen that each gun can be laid parallel to No. 4 gun by distribution, if No. 4 gun is treated as the directing gun and the angle DXC is treated as the angle of distribution for the battery.

All the guns can be brought, then, on to the required parallel zero lines by an order to switch the necessary degrees right or left.

In practice it is better to switch all the guns through the angle necessary to bring the directing gun on to its zero line, and then distribute, instead of vice versa.

For Example: Let the battery be a 4 gun battery; the angle $XDO = 210$ mils. and the angle $DXC = 8$ mils.

The order may be put on a piece of the battery chart, or passed down in some similar form:

The angle may be found by any of the following methods:

(1) From the map by protractor.

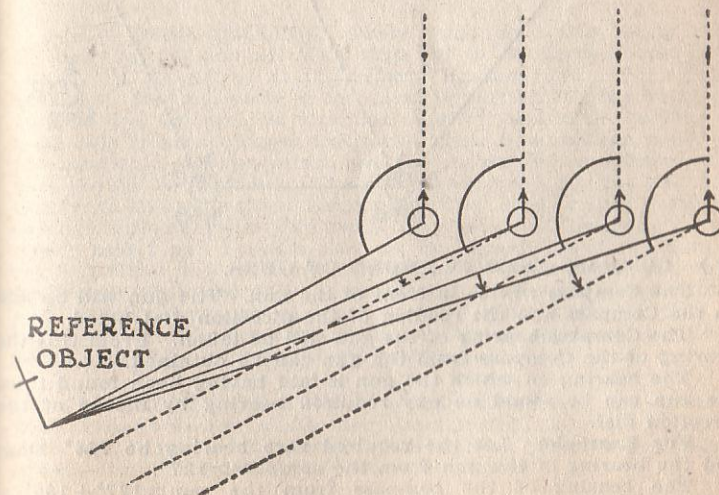
(2) By taking compass bearings to the R. O. from A and D.

(3) By ordering the flank guns first to lay on one another and then on the R. O., adding together the angles through which they have switched, and subtracting the angle thus found from 180° or 3,200 mils.

(iii.) REFERENCE OBJECT IN REAR OF BATTERY AND VISIBLE TO ALL GUNS.

(The guns must be approximately in line and at approximately equal intervals.)

In this case, lay all the guns on the Reference Object; distribute them on to lines parallel to that of the directing gun; then switch all the guns (on parallel lines) through the angle necessary to bring them on to the required bearing.



(iv.) REFERENCE OBJECT NOT VISIBLE TO ALL GUNS
AND/OR GUNS SCATTERED.

Two guns are only dealt with in the example.

The R. O. is visible from D, so that No. 4 gun can be laid on its zero line.

No. 4 gun is visible from C.

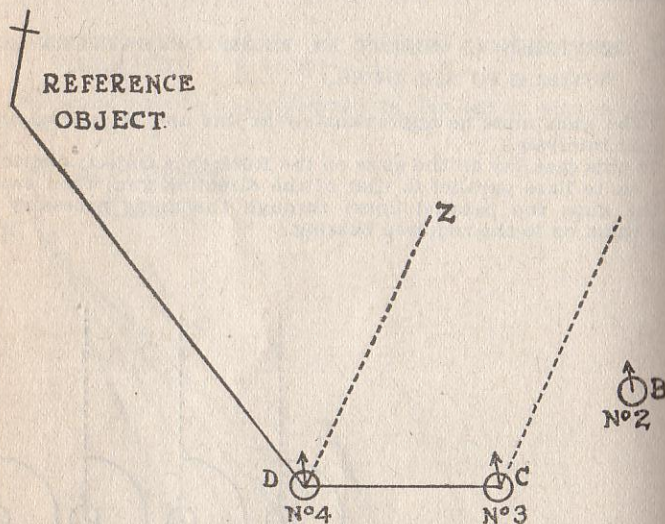
To lay No. 3 gun on a line parallel to D Z.

The two guns will first lay on one another.

No. 4 gun will then be relaid on its zero aiming post, and the angle through which it has been switched read off from the Direction Dial.

This angle will be subtracted from 180° or 3200 mils., and No. 3 gun will switch through the angle thus found. No. 3 gun will then be laid on a line parallel to D Z.

Any gun can be laid on its zero line provided that its No. 1 can see either the R. O. or a gun that has been laid on its zero line.



(v.) COMPASS USED IN FRONT OF GUNS.

The Compass will be in front of the gun. The gun will be laid on the Compass and the reading of the direction dial noted.

The Compass bearing of the gun will be taken. From this the bearing of the Compass from the gun can be obtained.

The bearing on which the gun is laid having been found thus the gun can be relaid on any required bearing by means of the direction dial.

For Example: Let the required zero bearing be 276° Mag and the bearing of the gun from the compass = 127° .

The bearing of the compass from the gun = $127^\circ + 180^\circ = 307^\circ$ Mag.

$$307^\circ - 276^\circ = 31^\circ$$

The gun must be laid 31° left from its present line.

(vi.) COMPASS AND POST, OR COMPASS AND COMPASS-TOWER.

7. ADMINISTRATIVE AND PRACTICAL CONSIDERATIONS.

(1.) **DUMPS AND S. A. A.** There will be Group and Battery dumps. After formation, the latter will fill up from the former, and it is the duty of the group commander to keep up his quota of ammunition and material from the rear. Dumps should be marked by notice boards as M. G. barrage dumps, and the location of each known to all ranks.

The group dump will be as near H. Q. as possible and should be under the control of an N. C. O. It will contain ammunition, of which there should be at least 100,000 rounds, spare parts, spare barrels (two per gun), spare water, rations, oil, sandbags, etc. The battery dumps should contain at least 15,000 rounds per gun, at least one spare barrel per gun, spare belts as many as possible, spare parts, sandbags, reserve of oil at the scale of one-half pint per gun.

BARRELS. The life of a barrel may be reckoned at about 15,000 to 20,000 rounds for overhead fire.

In the case of a forward move of the batteries, arrangements will be made to form forward dumps as early as possible during the operation. If possible, pack transport should be used as at MESSINES, but if the going is too bad, carrying parties under group arrangements must be organized. At the gun position where possible should be at least 16 filled boxes (belts), and 2,000 rounds (out of bandoliers), for belt filling by hand, eight gallons of water (in petrol tins), and one-half pint of oil, besides what is carried on the gun itself. On zero day and the day before zero day at least 15,000 to 20,000 rounds S. A. A. per gun will be required.

(ii.) **BELT FILLING.** There must be a belt filling center for each battery and not more than 200 to 300 yards in rear of the battery; it should be at the battery headquarters under cover if possible. As this work is the most important for the success of barrage fire, the greatest attention must be paid to this matter, and a suitable location chosen where the spare numbers can work with the minimum of discomfort and the maximum of shelter. Dug-outs should be provided. The line of approach for the belt filling centers to the guns should be concealed by every means possible as carriers will otherwise give away the location of the battery. Only Nos. 1 and 2 will be with the gun, the remainder of the crew being belt fillers and carriers. It is imperative that at no time should the supply of ammunition at gun or battery fall below its standard and battery commanders must be held responsible for this. As noted above an emergency 2,000 rounds of ammunition loose in boxes should be kept at the gun position.

(ii.) **RATES OF FIRE.** In this connection and to insure that gunners do not waste their ammunition, the rates of fire for each task must be laid down and entered on the Fire Organization orders and Barrage Charts. These rates are:

(1) "SLOW"—60 rounds per minute; the normal rate for barrage fire. This is found to be about the maximum rate that can be maintained for considerable periods.

(2) "RAPID"—250 rounds per minute. This is about the maximum rate that can be maintained for over a few minutes. It is used for S. O. S. when "Rapid Fire" is generally used for ten minutes, followed by "Slow Fire" for either about twenty minutes or until the situation clears. It is also used for short periods for harrassing fire.

(3) "MEDIUM"—120 rounds per minute. Used during a barrage for localities likely to give trouble or which needs special attention for other reasons.

The rate of fire for harrassing fire is about 1,000 rounds per gun every quarter of an hour. It is extremely important that gunners should be trained to control their rate of fire in this respect and this can only be done by practice.

(iv.) **TRAINING AND REHEARSALS.** Barrage work is very trying and all ranks need to be in good mental and physical condition. Officers and men must be trained in their special duties. The men should be specially trained in kit carrying, quick building and camouflaging of emplacements, belt filling in the dark, and the use of pack transport. Carriers, orderlies and scouts must receive special training in their work. Rehearsals of the actual barrage, and in taking on unexpected targets can be carried out on the 1,000 inch range. (See Appendix F.)

Full dress rehearsals behind the lines are of great importance as they bring out the points of supply, communication, etc. The M. Gs. should occasionally practice (in conjunction with artillery), part of their barrage actually at the Boche, otherwise the putting down of the M. G. barrage indicates at once that the zero hour has come. The actual barrage emplacements should not be used for these rehearsals.

(v.) **TRANSPORTATION AND CARRYING PARTIES.** The utmost use should be made of Pack Transport as much fatigue is hereby saved for the men. A mule can carry eight belt boxes, or six belt boxes and two petrol tins of water. The use of mules in the case of a forward move of the battery has been indicated. Carrying parties should be practiced in the use of the "Ukon Pack" during preliminary rehearsals. The need of infantry carrying parties being attached to the barrage group at least three weeks previous to being called on for actual work in an offensive action has been pointed out in Section 10, Paragraph 4.

(iv.) **EMPLACEMENTS.** Part III., Section 1, Sub-Sections 9, 23 and 32) The necessity of a forward move of the batteries may often be avoided by siting the barrage guns close up behind our own front line, only 400 to 500 yards in rear on the night be-

fore zero day. Such a method however, is risky unless special precautions are taken to avoid detection by hostile observation. It necessitates that there be no digging of emplacements or formations of dumps in the open previous to zero day, otherwise they will certainly be spotted. This was indicated on September 26th of last year in the YPRES offensive when 20 barrage guns of the 69th Division were dug in, shell slits provided for teams and ammunition brought up during "Z" night, commencing at 8:30 p. m. and finishing at 2:10 a. m. on zero day. During a two hours hostile bombardment from 3:15 to 5:15 a. m. no casualties were suffered by those guns or teams; other M. G. batteries in the same divisional front that prepared emplacements during "Y" day itself, suffered heavily and appeared to be under directly aimed fire, indicating that their work had been observed. Splinter proof emplacements will certainly be an advantage and prevent men "ducking" to avoid the shell bursts, but their construction must never sacrifice concealment, and "shell slits" are probably more efficient against a bombardment, when only a direct hit in the slit can cause casualties.

(vii.) **CLIMATIC ALLOWANCES.** Arrangements must be made daily with the artillery for the weather report, and the necessary allowances for the error of the day made. It should be the duty of the divisional M. G. officer to impart this information to the barrage groups.

(viii.) **ANTI-AIRCRAFT DEFENSE.** As the greatest menace to M. G. barrage work is the Aeroplane, careful arrangements must be made for the siting of machine guns for A. A. fire. These should be placed well to the flank of the batteries, and fire armour-piercing and tracer bullets. They will normally be provided by the Div. M. G. Bn.

(ix.) **MISCELLANEOUS.** Guns should be calibrated and new barrels tested. Watches should be synchronized. The time for this is usually stated in orders. Empty belts should not be allowed to fall on the ground, use sandbags or waterproof sheets. No. 1 must be relieved. The elevation of guns will be checked after the first 50 rounds and subsequently and each 1,000 rounds. Triangular bases for the tripod are essential.

(x) **LIASON AND COMMUNICATION.** This has been dealt within Part III., Section 1, Sub-Sections 17, 27 and 31, and in "Notes on the Organization of the machine guns within a division for Attack and Defense." (Part III., Section 4.)

APPENDIX A.

59TH DIVISION INSTRUCTIONS FOR THE OFFENSIVE.

INSTRUCTIONS NO. 9—MACHINE GUN ORDERS.

REFERENCE SPECIAL MAP.

1. **FIRE ORGANIZATION.** Firing will be carried out in accordance with the attached Fire Organization Schedules. No firing other than S. O. S. will take place should ammunition fall to below 8,000 rounds per gun.

2. **HEADQUARTERS.** Group Headquarters Right Group will be at POMMERN REDOUBT. Group Headquarters Left Group will be at POND FARM.

3. **LIAISON.** Advanced Brigade H. Q. 177th Brigade will be at BANK FARM. Advanced Brigade Headquarters 178th Brigade will be at CARRICORN KEEP. Group commanders will keep in close touch with attacking brigades, and will at once readjust S. O. S. barrages should it be necessary to do so. Any such adjustment will be at once reported.

4. **REPORTS.** Group commanders will report at zero minus 12 hours and every 12 hours after zero (i.) the amount of S. A. A. on hand, (ii.) number of unused barrels, (iii.) numbers of casualties.

5. **SAFETY PRECAUTIONS.** The elevation of guns will be checked after the first 50 rounds and each minute subsequently. When guns are shooting at an elevation of less than 40°, 30°, battery commanders must see that no infantry are within 100x of the guns.

6. **CALCULATIONS.** Group commanders will check all calculations. Copies of battery commanders' charts will be forwarded to D. M. G. O. by 6 p. m., 25th inst.

7. **ERROR OF THE DAY.** Should the error of the day be appreciable wind reports will be forwarded to group commanders. These will show

- (i.) Temperature.
 - (ii.) Strength of wind in miles per hour.
 - (iii.) True bearing of direction from which wind is blowing.
- Figures only will be sent.

8. **COMMUNICATION.** Group commanders will be connected with the buried cable system at BANK FARM and POND FARM.

They will also be in lamp communication with the main visual station at C.23.c.6.8. The word "Ginger" will be sent by lamps at 10 p. m. on the 25th inst. as a test word.

Group commanders will each detail one runner with rations for 48 hours to report at WIELTJE at 6 p. m., 25th inst., to remain for the operations.

9. **S. O. S.** S. O. S. lines will be as shown on attached map. Patrols will be sent out to OTTO FARM at O plus 198. If they do not occupy it the barrages of C & D batteries will be brought back to the line of the other S. O. S. barrages.

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SECRET

FIRE ORGANIZATION SCHEDULE

Copy No. 27

APPENDIX A

Battery Letter	Battery Comdr.	No. of Guns	Approx. Location	Time from Firing from	Time to Firing to	Targets	Rate of Fire per Gun per Minute	Total of S.A. expenditure	Remarks
A	2 | Lt. White	6	D.19.b.6.0	O O plus 2 hrs. 10 min. O plus 4 hrs.	O plus 2 hrs. O plus 4 hrs. Onwards	Gravenstafel Cross Rds Area D.15.b. 70.75-45- 50-80.00-D.16.a.2.2, S.O.S.	50 Rds 200 Rds. Bursts every 3 Minutes	36,000 44,000	All Guns to Fire Bursts together
B	Lt. Vint.	6	D.19.b.4.3	O 2 hrs. 10 minutes O plus 4 hrs.	2 hrs. O plus 4 hrs. Onwards	Boethoek & Bour- deaux fm. D.16.D.X S.O.S.	60 50	43,200 33,000	Area between these farms to be trav- ersed also
C	Lt. Withington	8	D.13.c.6.1	O O plus 2 hrs. O plus 4 hrs.	1 hr. 45 min. O plus 4 hrs. Onwards	Wimbleton Gravenstafel Cross Rds S.O.S.	40	33,600 83,400	
D	2 | Lt. Glishe- man	8	D.13.c.15.65.	O O 2 hrs. O plus 4 hrs.	O plus 1 hr 40m O plus 1 hr. 40m 4 hrs. Onwards	Otto Farm D.8.DZ. D.15.BW. S.O.S.	75 100 50	30,000 40,000 48,000	Half Guns on Otto Farm and half on 8 DZ.
E	2 | Lt. J. H. Iredale	6	C.13.a.30.00.	O O plus 52 O plus 4 hrs.	O plus 47 O plus 4 hrs. Onwards	Dochy Farm D.16.AX S.O.S.	60 50	18,900 55,400	
F	2 | Lt. Hobson	6	C.18.b.98.50	O O plus 10. O plus 4 hrs.	O plus 8 min. 4 hrs. Onwards	Van Jaackere Farm D.9.CY. S.O.S.	80 50	8,840 57,000	

Grand Total S. A. S. Expenditure - 430,340 Rds.

10. **SYNCHRONIZATION OF WATCHES.** Watches will be synchronized at Advanced Brigade Headquarters at 6 and 8 p. m. on "Y" day. Group commanders will also synchronize watches an hour before zero.

11. **HARRASSING FIRE.** No harrassing fire will be carried out on "Z" night.

D. M. G. O. Headquarters will open at 4 p. m. at WIELTJE, Dugout No. 35.

13. Acknowledge.

H. BASDEN, Major,

For Lieutenant Colonel G. S. 59th Division.

24.9.17.

Distribution—Normal.

Minus copies 11, 12, 13 and 15.

Plus copy No. 25 to C. M. G. O.

No. 26 to 174 M. G. Coy.

No. 27 to 175 M. G. Coy.

No. 28 to 177 M. G. Coy.

Map, FRANCE SHEET 57c 1:10,000

Composition No. 1-2, Plat A, Coy x,
M. G. Bn.

Commanded by Captain Smith

Location of Directing Gun C13a3.5

Number of directing Gun 8

**LEFT BARRAGE GROUP.
BATTERY BARRAGE CHART.**

BATTERY "G"

Battery frontage, 70 yards, OO

Grid bearing of zero lines, 185

Method of laying out zero lines.....

R. O. in front of gun

Appendix B.

Place	Date	TASKS
A	OTTO FARM	Creeping
B	D15 d x	Barrage
C		
D		
E	S. O. S.	
F		

Task	Guns	TARGET	Clock Time	Zero Time	Angle of Switch	Angle of Distribution	Range	V. I. Meters	Q. E. Mils.	Traverse per Gun
A	8	Otto Farm		Z to Z+10	0	12 Mils	1800	+8	50.5	
B	8	D.15.d.x.		Z+15 to Z+45	101 Mils. Rt.	15 Mils	see elevation			
C										
D										
E	8	D.14.b.8.7. D.15.a.2.5.				10 Mils	2400	+12	89	

ANGLE OF SWITCH

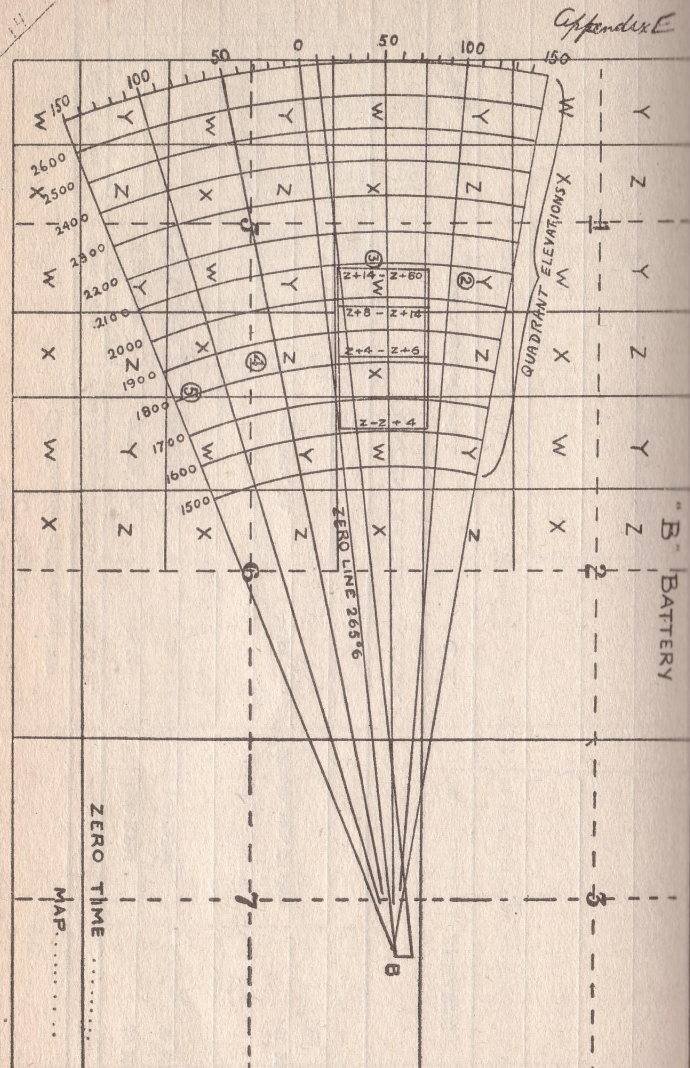
ELEVATION

Task	No. 8	No. 7	No. 6	No. 5	No. 4	No. 3	No. 2	No. 1	No. 8	No. 7	No. 6	No. 5	No. 4	No. 3	No. 2	No. 1
A	O	12 rt.	24	36	48	60	72	84								
B	101 Rt	117	133	149	165	181	197	213	51	54	57	60	63	66	69	72
C																
D																
E	52 Lt.	42	32	22	12	2	8 Rt.	18 Rt.								

S.O.S. S.O.S. S.O.S.

KEY
BATTERY
BG- POSITIONS
② POSSIBLE
CONCENTRATION
POINTS

CONCENTRATION POINTS.



N.B. Note Sub-squaring of the map into 250" squares X, Y, etc.

APPENDIX F.

TO PREPARE A TARGET FOR USE AT 1,000 INCH RANGE.

(ELEMENTARY BARRAGE DRILL B.)

PREPARATION OF THE TARGET.

- (i.) Work out the QE's and mils. of traverse for each task.
- (ii.) Find by trial with what reading on the tangent sight the shots will strike the point of aim at a range of 1,000 inches.
- (iii.) Place the gun 1,000 inches from the target, which will be a white screen 6 ft. by 4 ft.
- (iv.) With the clinometer, put the elevation for the first task on the gun. (Holding pressure will not be taken.)
- (v.) With the slide at the reading found as described in (ii.) above, note where the line of sight cuts the target, and mark this point on the target. The limits of traverse for this task may be marked on the target by noting where the line of sight cuts the target when the gun is laid on its limits of traverse by means of the direction dial.

(vi.) The same method will be adopted to mark the subsequent tasks on the target.

Note. Before firing the practice, the Q. E. for each gun for the initial task must be found by firing, and allowance made for variations (from the Q. E. of the first gun used) in putting on the elevation for the subsequent tasks.

In firing the practice it will be found convenient to place the guns six feet apart (from crosshead to crosshead) and to lay each gun on the center of the target. The auxiliary aiming mark for each gun will then be placed in alignment with the sights.

EXAMPLE OF TASKS.

The Instructor may draw up a list to include any type of task, and can, if necessary, prepare a target in such a way as to enable him to practice his men in carrying out, on a short range, a barrage they are going to fire in an attack.

EXAMPLE OF TASKS FOR 4 GUNS.

(A) 4 guns barrage the German 2nd line, while Infantry assault the German 1st line. (Z to Z)

(B) 4 guns lift and barrage the German 3rd line while Infantry assault the German 2nd line. (Z to Z)

APPENDIX G.

SOME AUXILIARY AIMING MARKS.

T-SHAPED AIMING MARK.

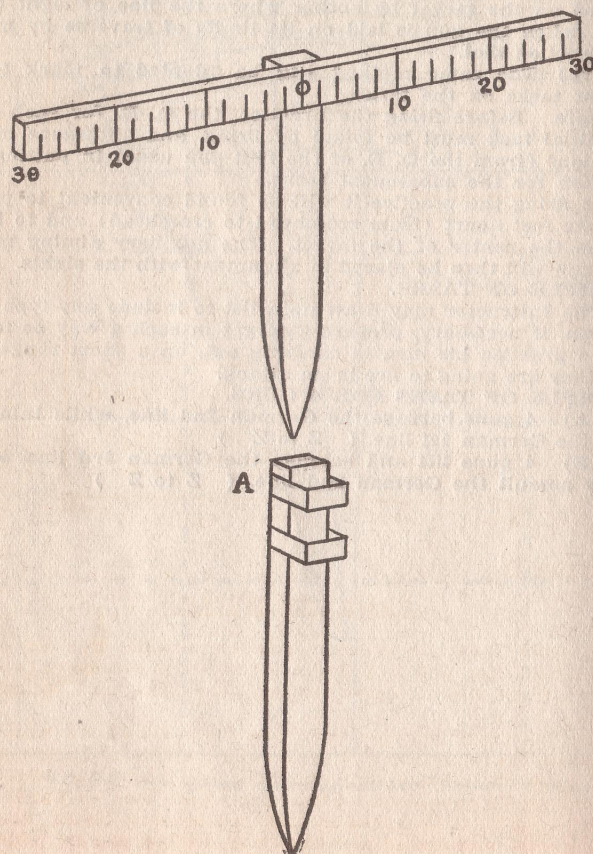
This auxiliary aiming mark is made of wood, except for the parts marked A and B, which are of iron.

It can be used with or without the lower post, according to the height at which the horizontal arm is needed.

It is placed 14 yards from the crosshead, and the 5-inch graduations thus give a traverse of 10 mils., and the 1-inch graduation a traverse of 2 mils.

A bull is marked on the center, and other bulls may be fixed on the horizontal arm to mark the centers of the traverses for the different tasks.

The gun commander will usually be able to place the T-shaped aiming mark so that it will not need to be moved unless a switch of over 40 mils. is required.



SPECIALLY PREPARED SCREEN FOR A SET PIECE.

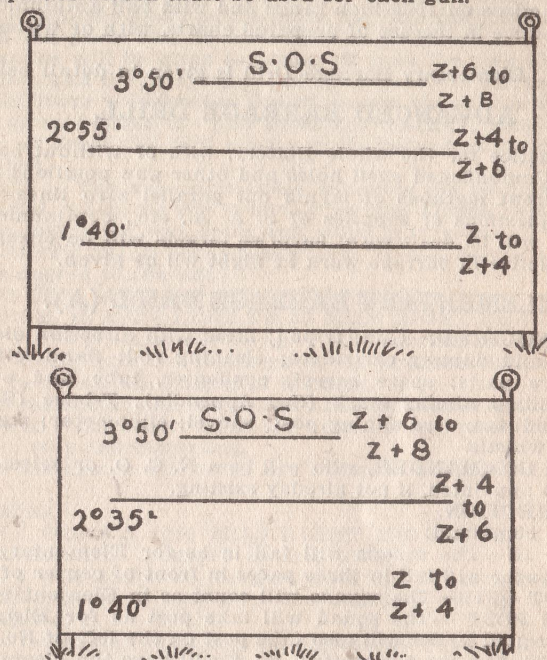
Work out the Q. E.'s and degrees of traverse for each task.

Take a screen of any suitable material. If the screen is to be placed 14 yards from the crosshead, 5 inches on the screen will give 10 mils. of traverse on the target.

The clinometer will be used in every case to put on elevation, the lines on the screen being used for maintaining elevation and for giving limits of traverse.

The screen prepared as described and illustrated is a combined gun chart and auxiliary aiming mark.

A separate screen must be used for each gun.



APPENDIX H.

BARRAGE DRILL.

In order that the greatest possible results may be obtained from barrage fire, and to prevent errors, it is necessary to drill all ranks in their special duties before they take part in an actual barrage.

The following Barrage Drill has been drawn up with a view to assisting Machine Gun Officers in the training of their men.

If properly carried out, the drill will stimulate interest and make all ranks proficient for the particular task in hand; it will, in addition, give them speed in sight setting and laying; the use of direction dial, clinometer and auxiliary aiming marks; lifting from one barrage to another; switching from one target to another and points during firing a barrage.

The drill has been divided into two stages: Elementary and advanced. In the elementary stage, it is assumed that all the necessary calculations have already been made by the officer and the practices are confined to the duties of the gun commanders and the gun numbers. In the advanced stage, the whole personnel of the Battery take part, and service conditions should be attained as nearly as possible. (A battery may consist of 4, 6 or 8 guns.)

ELEMENTARY BARRAGE DRILL.

A. Practices conducted on the barrack square and without ball ammunition.

B. Practices on 1000-inch range and with ball ammunition.

C. Practice in the use of prepared charts, with or without ball ammunition.

NOTE: Elementary Barrage Drill is given in detail below.

ADVANCED BARRAGE DRILL.

A. Practice for the whole Battery, with or without ball ammunition. Camouflaged shell holes and other gun positions will be used. Different methods of laying out parallel zero lines will be practiced; questions of supplies of S. A. A., etc., communications, and control will be dealt with; surprise targets will be engaged.

B. Practice in barrage work at night will be given.

ELEMENTARY BARRAGE DRILL (A).

KIT REQUIRED: Gun; tripod; fitted with direction dial; belt boxes, belt and dummy cartridges; cleaning rod; flannelette; oil; water; spare parts; spare barrel; condenser, tube and box; T-shaped auxiliary aiming mark (See Appendix); T-base (See Appendix); sandbags; zero aiming post; shovel; clinometer; signalling shutter; or whistle.

A GUN COMMANDER, who will be a N. C. O. or selected private, will be appointed, if not already existing.

A. 1. DIRECTION.

On the command:

"FALL IN"—The squads will fall in as for Elementary Drill; the squad leader will fall in three paces in front of center of squad.

"COUNT OFF"—The squads will count as in Elementary Drill.

"TAKE POST"—The squad will take post as for Elementary Drill. The squad leader will also take post on the left of No. 1, and will have with him the clinometer. No. 3 will have the cleaning rod, No. 4 will place sandbags over the shoes of the tripod.

"MOUNT GUN"—No. 4 will first place the T-Base in position. The gun will then be mounted on the T-base.

No. 3 will bring up the ammunition, cleaning rod and condenser box.

No. 4 will place sandbags over the shoes of the tripod.

NOTE: After the gun has been mounted, all orders will be repeated by the squad leader.

The instructor will indicate a reference object and practice will be given in laying off from it.

"REFERENCE OBJECT:"

No. 1 will lay on the Reference Object, and No. 2 will note the Reading of the Direction Dial.

The instructor and the gun commander will check.

"ALL GUNS—X MILE RIGHT (OR LEFT)."

No. 2 will watch the Direction Dial, and tell No. 1 when he has switched his gun through the angle ordered.

The instructor and the gun commander will check.

NOTE: If the gun has to be switched through a small angle No. 1 will tap; if the angle is great, No. 2 will loosen the traversing clamp until the gun is laid in the required direction.

"ZERO POSTS OUT."

Instructor will order the zero aiming posts to be put out. These will be so placed that, when each gun lays on its zero aiming posts, all the guns are laid on parallel lines. The posts must therefore be the same distance apart as the guns; for drill purposes the distance between the posts may be measured by pacing.

Practice will be given in laying off from the zero aiming posts. The orders and the carrying out of the orders will be the same as in laying off from a Reference Object, except that the order "ZERO" will be given instead of "REFERENCE OBJECT," and the No. 1's will lay off from the zero aiming posts instead of from the reference object.

NOTE: The gun commander will note the reading of the direction dial, when the gun is laid on its zero aiming post.

The instructor will order any suitable traverse.

"THIRTY MILS TRAVERSE"—(i. e. one degree to the right and one degree to the left.)

"TO THE LEFT—30 MILS TRAVERSE."

"FROM 15 MILS LEFT TO 30 MILS RIGHT TRAVERSE."

No. 1 will practice traversing by taps between the limits ordered. No. 2 will note the readings on the direction dial, and tell No. 1 when he reaches his limits of traverse.

The instructor and the gun commander will check.

NOTE: The order "STEADY" will be used when the instructor wishes to stop the traversing.

The instructor will order the T-shaped aiming mark to be put out.

"ZERO."

"ALL GUNS X (15) MILS RIGHT (OR LEFT)."

"AUXILIARY AIMING MARK OUT."

No. 3 will double to the gun, pace out 500 inches or 14 yards from the crosshead, and erect the auxiliary aiming mark, as directed by No. 1.

The instructor and the gun commander will check.

The instructor will order the guns to be laid on any part of the horizontal arm of the T-shaped aiming mark; e. g.

"CENTER."

"ALL GUNS—15 MILS RIGHT."

The instructor and the gun commander will check.

The instructor will order limits of traverse as before. No. 1 will limit his traverse by means of the graduation on the arm of the T-shaped aiming mark. No. 2 will note the readings on the direction dial and thus check mils traverse.

NOTE: Practice will be given in the use of traversing stops, when these are available.

A. 2. ELEVATION.

The gun will be laid for direction (A.1).

The Instructor will order any suitable elevation to be put on the gun.

"ELEVATION—20 MILS."

The gun commander will put on elevation ordered with the clinometer, No. 1 maintaining holding pressure. No. 1 will run up

the tangent sight slide until his sights are aligned on the auxiliary aiming mark and will note the reading on the tangent sight.

The instructor and the gun commander will check.

NOTE: Practice will be given in the use of depression stops when these are available.

The Instructor will give the order to load, the limits of traverse, the rate of fire. Practice will then be given in traversing between the limits ordered. The signals to open fire and to cease fire will be given by whistle, signalling shutter, or arm signal.

"LOAD."

No. 1 will load and check his aim.

"20 MILS TRAVERSE."

"SLOW RATE."

Squad leader and No. 1 repeat all commands after gun is mounted.

When the signal to fire has been given, No. 1 will fire and traverse. "Cease Fire" will be ordered at intervals. The instructor and gun commander will check the aim, and the instructor will criticize the rate of fire and the duration of pressure on the thumb piece.

NOTE: Slow rate= 60 rounds per minutes.

Medium rate=120 rounds per minute.

Rapid rate=250 rounds per minute.

The instructor will occasionally give the order:

"BELT FINISHED."

No. 1 will unload, clear the gun and oil the face of the lock, the lock guides, extractor and recoiling portions. At night or in well concealed positions No. 2 will wipe out the bore.

No. 2 will examine the adjustment of the muzzle cap after the first belt and again after every four belts.

No. 1 will reload and relay.

The instructor and the gun commander will check the aim and will check the elevation with the clinometer.

No. 1 will reopen fire.

A. 3. SWITCHES.

Practice will be given in switches from one direction to another. The guns will need to be relaid on the Zero aiming posts. The order "ZERO" will give No. 3 warning that the T-shaped aiming mark will have to be moved.

"ZERO."

"ALL GUNS—X MILS RIGHT (OR LEFT)."

No. 3, directed by No. 1, will move the auxiliary aiming mark into alignment with the sights.

A. 4. LIFTS.

Practice will be given in lift from one elevation to another. The signal, "CEASE FIRE" will be given, followed by the order for the next elevation. Limits of traverse and rate of fire for this elevation will be given, and the practice will be carried on as described above. The elevation will in every case be put on by means of the clinometer, as in A. 2.

All foregoing practices will be combined when practice has been given in each.

Watches synchronized.

ELEMENTARY BARRAGE DRILL (B).

KIT REQUIRED—As for Elementary Barrage Drill (A), and in addition ball ammunition and an especially prepared target.

Guns will be mounted on T-base, dug into the ground 1000 inches from the target.

T-shaped aiming marks or especially prepared screens (See Appendix) will be used.

ELEMENTARY BARRAGE DRILL (C).

KIT REQUIRED—As for Elementary Barrage Drill (A) with the addition of Gun charts and Battery charts. (Appendix).

The guns will be mounted on T-bases, and the zero aiming posts will be put out as in Elementary Barrage Drill (A).

Practice will be given in the use of Gun charts.

Prepared Gun charts will be given to the gun commanders.

On the order "BARRAGE A" the guns will be loaded and laid for that task both for direction and elevation.

The instructor will check.

The signals to fire and cease fire will be given as in Elementary Barrage Drill (A).

The other tasks will be carried out in a similar way.

Practice will be given in carrying out all the tasks on the Gun charts to the time table.

The gun commanders will use their watches to time the tasks both with and without the assistance of signals given by the instructor by means of his whistle or signalling shutter.

The instructor will signal "CEASE FIRE" at intervals and check.

Practice will be given in switching on to a target not included among the tasks on the Gun charts. Some of these switches should necessitate the moving of the T-shaped aiming mark.

The instructor will fill in the lower part of a Battery chart, showing the direction and elevation of each gun for the new task.

The Battery chart will be sent by orderly to each gun commander in turn. Each gun commander will note and carry out the instruction for his gun, and will report "Ready to Fire" to the instructor, either by word to the orderly on his return journey to the instructor or by some other means.

The instructor will check

Orders to fire, etc., will be given as in the preceding practices.

SEARCHING REVERSE SLOPES
TABLE I.

Meters—

Guns Above Crest	12	11	10	9	8	7	6	5	4	3	2	1
0	1950	1900	1800	1750	1650	1550	1500	1350	1250	1200	1150	1100
10	2100	2050	2000	1950	1850	1800	1700	1650	1550	1500	1400	1250
20	2050	2000	1950	1900	1800	1750	1700	1600	1500	1400	1300	1200
30	2050	2000	1900	1850	1800	1700	1650	1550	1450	1350	1200	1100
40	2000	1950	1900	1850	1750	1650	1600	1500	1400	1250	1150	1000
50	2000	1950	1850	1800	1700	1600	1550	1450	1300	1200	1050	
60	2000	1900	1850	1750	1650	1600	1500	1350	1250	1100		
70	1950	1850	1800	1700	1650	1550	1450	1300	1200	1000		
80	1900	1850	1750	1700	1600	1550	1400	1250	1100			
90	1900	1800	1700	1650	1550	1450	1300	1200				
100	1850	1750	1700	1600	1500	1400	1250	1100				
110	1800	1750	1650	1550	1450	1300	1200	1000				
120	1800	1700	1600	1500	1400	1250	1100					
130	1750	1650	1550	1450	1350	1200	1050					
140	1700	1600	1500	1400	1300	1150	1000					
150	1700	1600	1450	1350	1200	1100						
160	1650	1550	1400	1300	1150	1000						
170	1600	1500	1400	1250	1100							
180	1550	1450	1350	1200	1000							
190	1500	1400	1300	1100								
200	1450	1350	1250	1050								
210	1400	1300	1200	1000								

SEARCHING REVERSE SLOPES TABLE II.

Meters—

1	2	3	4	5	6	7	8	9	10	11	12	Guns Below Crest
1450	1600	1650	1700	1750	1750	1900	2000	2100	2100	2150	2200	0
1250	1400	1500	1550	1650	1700	1800	1850	1950	2000	2050	2100	10
1350	1450	1550	1600	1700	1750	1800	1900	1950	2000	2050	2150	20
1450	1500	1600	1700	1750	1800	1850	1950	2000	2050	2100	2150	30
1500	1600	1650	1750	1800	1850	1900	1950	2050	2050	2150	2200	40
1600	1650	1700	1750	1800	1900	1950	2000	2050	2100	2150	2200	50
1650	1700	1750	1800	1850	1900	2000	2050	2100	2150	2200	2250	60
1700	1750	1800	1850	1900	1950	2000	2050	2100	2150	2200	2250	70
1750	1800	1850	1900	1950	2000	2050	2100	2150	2200	2250	2300	80
1800	1850	1900	1950	2000	2000	2100	2150	2150	2200	2250	2300	90
1900	1900	1950	2000	2000	2050	2100	2150	2200	2250	2300	2300	100
1950	1950	2000	2000	2050	2100	2150	2200	2200	2250	2300	2350	110
2000	2000	2000	2050	2100	2150	2150	2200	2250	2300	2350	2350	120
2050	2000	2050	2100	2100	2150	2200	2250	2250	2300	2350	2400	130
2050	2050	2100	2150	2150	2200	2200	2250	2300	2350	2350	2400	140
2100	2100	2150	2150	2200	2200	2250	2300	2300	2350	2400	2450	150
2150	2150	2200	2200	2200	2250	2250	2300	2350	2400	2400	2450	160
2200	2200	2200	2250	2250	2300	2300	2350	2350	2400	2450	2450	170
2250	2200	2250	2250	2300	2300	2300	2350	2400	2400	2450	2500	180
2300	2250	2250	2300	2300	2350	2350	2400	2400	2450	2450	2500	190
2350	2300	2300	2300	2350	2350	2400	2400	2450	2450	2500	2550	200
2350	2300	2300	2350	2350	2400	2400	2450	2450	2500	2500	2550	200

NOTES.

1. The top horizontal line is the drop in meters in the first 100 meters beyond the crest. The horizontal line directly below it is the distance back from the crest to find gun position.

2. Explanation of use of table.

EXAMPLE: The ground drops 7 meters in 100; assume also that the gun is below the crest. Table 2 must therefore be used. The table shows that for a drop of 7 meters we must go back 1900 meters from the crest. At this point, say, the gun position is found to be 90 meters below the crest. Final range, therefore, equals

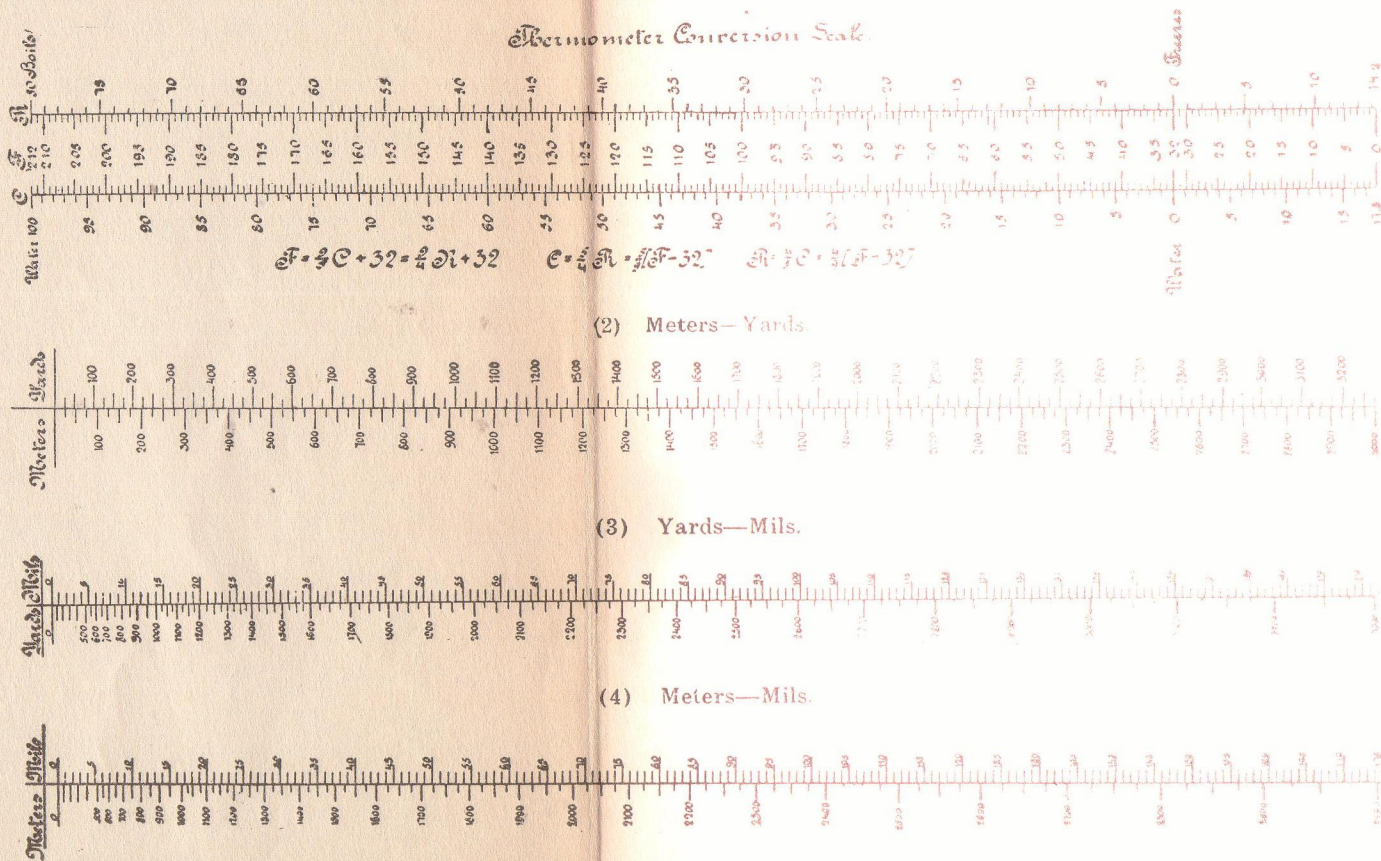
3. Searching should be employed away from the crest, but it must be remembered that as the cone strikes falling ground, the length of zone will be very much increased, therefore, the turns of the hand wheel should be few in number.

4. If the final position is not suitable the gun should be moved farther away from, not nearer to, the crest, the elevation should be increased by the distance moved.

5. If it be desired to engage an area of ground which lies some distance back from the crest, without searching back from the crest itself, the position of the gun must be determined with reference to the crest as detailed above. Then the quadrant elevation necessary to hit the near limit of the ground, to be searched must be applied in the usual way for indirect fire.

GRAPHICAL CONVERSION SCALES

(1) Thermometer



(2) Meters—Yards.

(3) Yards—Mils.

(4) Meters—Mils.

Examples:

- (1) **Thermometer:** (F=Fahrenheit; C=Centigrade or Celsius;
R=Réaumur.)

$$\begin{aligned}
 &56^{\circ} \text{ F} = \frac{56-32}{9} \times \frac{5}{9} = 13.33^{\circ} \text{ C}; \\
 &= \frac{56-32}{9} \times \frac{4}{5} = 10.66^{\circ} \text{ R} \\
 &28^{\circ} \text{ C} = \frac{28}{5} + 32 = 82.4^{\circ} \text{ F} = \frac{112}{5} = 22.4^{\circ} \text{ R} \\
 &34^{\circ} \text{ R} = \frac{9 \times 34}{4} + 32 = 108.5^{\circ} \text{ F}; \\
 &= \frac{5 \times 34}{4} = 42.5^{\circ} \text{ C}.
 \end{aligned}$$

- (2) **Meters—Yards:**

$$\begin{aligned}
 1 \text{ yard} &= 0.914399 \text{ meter} \\
 1 \text{ meter} &= 1.09361 \text{ yards} \\
 100 \text{ yards} &= 91.44 \text{ meters}; & 1500 \text{ yards} &= 1371 \text{ meters} \\
 100 \text{ meters} &= 109.4 \text{ yards}; & 1800 \text{ meters} &= 1968 \text{ yards}
 \end{aligned}$$

- (3) **Yards—Mils:**

$$\begin{aligned}
 \text{Angle of departure for 1600 yds} &= 35.5 \text{ mils.} \\
 74.4 \text{ mils} &= \text{angle of departure for 2275 yards.}
 \end{aligned}$$

- (4) **Meters—Mils:**

$$\begin{aligned}
 \text{Angle of departure for 1800 meters} &= 54.6 + \text{mils} \\
 174.2 \text{ mils} &= \text{angle of departure for 3000 meters.}
 \end{aligned}$$

**OTHER USES OF
METERS—MILS (OR YARDS—MILS) SCALE**

- (a) **Use as Graph for Determining any Ordinate of any Trajectory:**
From mil equivalent of trajectory used, subtract mil equivalent of abscissa to ordinate. Result is ordinate in mils; convert this to meters, yards, or feet by multiplying ordinate in mils by abscissa in meters, yards, or feet and move decimal point 3 places to left.

Example: 700 meter ordinate of 1200 meter trajectory in meters.

$$\begin{aligned}
 1200 \text{ m} &= 23.8 \text{ mils.} \\
 700 \text{ m} &= 8.8 \text{ mils.}
 \end{aligned}$$

$$\begin{array}{r}
 15.0 \text{ mils.} \\
 \hline
 700
 \end{array}$$

10500.0 meters, ordinate sought.

- (b) **Use as Graph for Determining Sight Setting for Use with Auxiliary Aiming Target:**

Measure angle in mils between target and aiming target and add to graphical mil value of range if aiming target is below target; subtract if aiming target is above target.

Example: Angle between target and aiming target=5 mils; range 1200 meters.

$$\begin{aligned}
 1200 \text{ meters} &= 23.8 \text{ mils.} \\
 5.0 \text{ mils aiming target below target.} &
 \end{aligned}$$

$$\begin{array}{r}
 28.8 = 1320 \text{ meters.} \\
 \hline
 \end{array}$$

$$\begin{aligned}
 1200 \text{ meters} &= 23.8 \text{ mils.} \\
 5.0 \text{ mils (aiming target above target.)} &
 \end{aligned}$$

$$\begin{array}{r}
 18.8 = 1050 \text{ meters.} \\
 \hline
 \end{array}$$

(c) Use as Graph for Determining Quadrant Elevation for Use with Spirit Level:

Measure angle of site in mils to target and add graph value of range in mils.

Example: Angle of site = + 3 mils; Range 1000 meters.

Target above gun	Target below gun
1000 meters = 16.6 mils	16.6 mils
3.	3.

19.6 mils = 1089 meters	13.6 mils = 900 meters
-------------------------	------------------------

(d) Use in Construction of the Ordinate Stick:

Secure a pine stick similar to a yard stick, about 38 inches long. This stick may be beveled on the edge in order to obtain more accurate measurements.

Mark a point 1 inch from the bottom end of the stick. This will be the point from which all measurements are made and is the 00 range. Graduate the stick on the right edge in inches.

Using the scale for "Meters-Mils" lay off, from this 00, the ordinates corresponding to the ranges given thus:

Measure from the 00 up .78 of an inch and mark this point 100.

Measure from the 00 up 1.67 inches and mark this point 200.

Measure from the 00 up to 2.7 inches and mark this point 300.

This is continued until the entire left side is graduated; the figures from 100 up representing the range for the angle of departure measured in inches on right side of stick.

At the points:

1.7 inches (mils) mark Zero—Colt.

2.4 inches (mils) mark Zero—Lewis.

4.3 inches (mils) mark Zero—Vickers.

With the sight set at the ranges corresponding to these mils the bullet will hit the point at which aim is taken on the 1000 inch range.

The graduations on the left should be marked "Ordinates"; those on the right "Mils or Inches," and the stick, "Ordinate Stick for Lewis (Colt, Vickers) Machine Gun, Caliber .30"

MASK CLEARANCES
(Par. 122, Prov. M. G. F. M. 1917)

Range Meters	Mils	Meters	Range Meters	Mils	Meters
100	2.6	.28	1600	4.15	6.6
200	2.6	.57	1700	4.55	7.7
300	2.6	.85	1800	5.	9.
400	2.6	1.1	1900	5.5	10.5
500	2.6	1.4	2000	6.2	12.4
600	2.6	1.7	2100	7.	14.7
700	2.6	2.	2200	7.9	17.4
800	2.6	2.3	2300	9.3	21.4
900	2.7	2.6	2400	10.9	26.2
1000	2.8	2.8	2500	12.9	32.2
1100	2.9	3.2	2600	15.2	39.5
1200	3.	3.6	2700	17.5	47.2
1300	3.2	4.2	2800	20.	56.
1400	3.5	4.9	2900	22.5	66.
1500	3.83	5.6	3000	25.	75.

Use: Determine height of mean trajectory above mask. If greater than, or equal to, tabular clearances, mask will be cleared.

Example: Angle of site +3 mils; target at 1000 meters, mask angle +5 mils at 500 meters.

Angle of departure 1000 meters=16.6 mils.
3. mils.

19.6 mils.
5.3 mils=range to mask.

14.3 mils=ordinate at mask.
5.0 mils=height of mask.

9.3 mils=height of trajectory above mask.
2.6 mils=tabular clearance.
6.7 mils x 500=3.35 meters over required clearance.

1000

TROOP CLEARANCES
(Par. 125, 126 and 127 Prov. M. G. F. M. 1917)
TABLE OF SAFETY ANGLES

Distance to Troops (Meters)	Safety Angle		Distance to Troops (Meters)	Safety Angle	
	Mils	Corresponding Range		Mils	Corresponding Range
75	98.	2362	1100	41.2	1571
100	73.6	2070	1200	46.6	1667
200	40.1	1550	1300	52.8	1770
300	30.0	1345	1400	59.6	1875
400	26.1	1251	1500	67.1	1983
500	24.4	1215	1600	75.2	2088
600	24.4	1215	1700	83.9	2199
700	26.4	1262	1800	93.3	2307
800	29.	1325	1900	104.1	2422
900	32.5	1400	2000	115.8	2538
1000	36.5	1482			

Example: Angle of site +12 mils; target 1400 meters; troop angle +11.1 mils at 900 meters.

Angle departure for 1400 meters=32.5 mils.

12. " angle of site.

44.5 " quadrant elevation to target.

11.1 " angle of site to troops.

33.4 " resulting safety angle.

32.5 " required safety angle.

.9 " x 900=.81 meters excess over required clearance.

1000

ORDINATES OF TRAJECTORY IN METERS
 Minus Ordinates above Zero in Bold Type; Plus Ordinates below Zero in Light Type.

Range Meters	Distance—Meters.													
	100	200	300	400	500	600	700	800	900	1000	1100	1200	1300	1400
100	0	.195	.593	1.265	2.285	3.717	5.641	8.223	11.577	15.819	21.247	27.595	35.284	44.277
200	.083	0	.325	.907	1.831	3.170	4.995	7.506	10.783	14.934	20.279	26.537	34.136	43.041
300	.185	.192	0	.499	1.319	2.555	4.215	6.661	9.862	13.911	19.148	25.305	32.803	41.606
400	.303	.430	.338	0	.723	1.839	3.469	5.751	8.795	12.727	17.546	23.886	31.268	39.989
500	.443	.706	.754	.527	0	1.007	2.503	4.643	7.556	11.350	16.330	22.234	29.473	38.071
600	.606	1.033	1.238	1.171	.772	0	1.371	3.351	6.102	9.732	14.547	20.296	27.369	35.757
700	.795	1.413	1.811	1.924	1.709	1.106	0	1.830	4.333	7.829	12.456	18.009	24.890	33.088
800	1.021	1.864	2.482	2.828	2.842	2.446	1.525	0	2.372	5.593	9.994	15.320	21.982	29.956
900	1.279	2.380	3.259	3.873	4.149	4.005	3.346	2.042	0	2.996	7.131	12.203	18.601	26.313
1000	1.578	2.977	4.156	5.066	5.639	5.799	5.481	4.421	2.651	0	3.858	8.622	14.745	22.200
1100	1.916	3.652	5.169	6.417	7.327	7.821	7.795	7.127	5.691	3.361	0	4.575	10.334	17.410
1200	2.293	4.408	6.303	7.929	9.217	10.088	10.440	10.150	9.090	7.137	4.145	0	5.431	12.135
1300	2.710	5.241	7.552	9.594	11.298	12.585	13.353	13.477	12.834	11.297	8.719	4.952	0	6.445
1400	3.165	6.151	8.917	11.413	13.572	15.315	16.536	17.112	16.924	15.841	13.716	10.402	5.838	0
1500	3.658	7.138	10.398	13.388	16.039	18.272	19.989	21.062	21.366	20.774	19.142	16.317	12.248	6.814
1600	4.192	8.205	11.999	15.522	18.709	21.473	23.725	25.333	26.166	26.109	25.006	22.713	19.176	14.272
1700	4.768	9.357	13.725	17.825	21.588	24.928	27.751	29.930	31.337	31.816	31.324	29.605	26.636	22.305
1800	5.385	10.593	15.578	20.296	24.671	28.631	32.073	34.868	36.893	38.003	38.110	37.002	34.646	30.927
1900	6.047	11.912	17.565	22.944	27.980	32.603	36.708	40.164	42.843	44.644	45.385	44.932	43.233	40.170
2000	6.692	13.334	19.692	25.781	31.530	36.862	41.669	45.830	49.225	51.722	53.169	53.426	52.429	50.066
2100	7.513	14.855	21.972	28.818	35.325	41.415	46.982	51.900	56.047	59.298	61.502	62.508	62.268	60.654
2200	8.323	16.402	24.414	32.026	39.317	46.269	52.644	59.615	63.699	67.436	70.439	72.256	72.814	72.050
2300	9.205	18.232	27.039	35.002	42.958	51.540	58.791	65.390	71.218	76.147	80.023	82.703	84.126	84.177
2400	10.139	20.105	29.845	39.311	48.440	57.147	65.328	72.862	79.620	85.470	90.275	93.883	96.225	97.192
2500	11.143	22.108	32.848	43.315	53.442	63.149	72.329	80.860	88.612	95.458	101.252	105.842	109.172	111.121
2600	12.229	24.257	36.069	47.610	58.808	69.583	79.832	89.429	98.242	106.153	113.009	118.654	123.040	126.042
2700	13.382	26.559	39.520	52.209	64.560	76.482	87.879	98.617	108.575	117.611	125.615	132.396	137.911	142.034
2800	14.606	29.030	43.229	57.155	70.738	83.892	96.517	108.484	119.669	129.929	139.148	147.147	153.869	159.198

ORDINATES OF TRAJECTORY IN METERS
Minus Ordinates above Zero in Bold Type. Plus Ordinates below Zero in Light Type.

Range Meters	Horizontal Distance—Meters.													
	1500	1600	1700	1800	1900	2000	2100	2200	2300	2400	2500	2600	2700	2800
100	55.010	67.218	81.184	97.047	114.982	135.033	157.594	182.749	210.041	241.444	275.308	312.461	353.365	398.208
200	53.685	65.803	79.680	95.454	113.284	133.336	155.743	180.806	208.511	239.343	273.036	310.160	350.977	395.728
300	52.147	64.163	77.937	93.603	111.331	131.288	153.593	178.544	203.154	236.981	270.534	307.499	348.210	392.858
400	50.445	62.273	75.924	91.479	109.088	128.920	151.106	175.949	203.493	234.045	267.532	304.425	345.018	389.549
500	48.405	60.065	73.575	88.993	106.470	126.167	148.207	172.922	202.421	230.736	264.131	300.839	341.295	385.689
600	45.884	57.477	70.829	86.147	103.416	122.934	144.315	169.366	196.702	226.857	260.039	296.638	336.932	381.162
700	43.025	54.428	67.594	82.693	99.792	119.123	140.319	165.176	192.323	222.284	255.327	291.683	331.789	375.831
800	39.667	50.846	63.785	78.625	95.527	114.642	135.117	160.245	187.172	216.912	249.728	285.857	325.737	369.560
900	35.765	46.683	59.364	73.945	90.582	109.493	130.651	154.521	181.188	210.666	243.226	279.095	318.714	362.274
1000	31.222	41.914	54.296	68.581	84.955	103.489	124.663	147.975	174.336	203.514	235.778	271.350	310.673	353.937
1100	26.229	36.509	48.652	62.500	78.507	96.727	117.301	140.533	166.559	195.410	227.325	262.566	301.551	344.471
1200	20.556	30.458	42.130	55.698	71.320	89.171	109.361	132.225	157.866	186.334	217.878	252.735	291.346	333.891
1300	14.319	23.807	35.059	48.210	63.420	80.851	100.629	123.072	148.307	176.355	207.484	241.921	280.113	322.238
1400	7.504	16.541	27.333	40.035	54.787	71.767	91.095	113.080	137.858	165.451	195.126	230.114	267.851	309.530
1500	0	8.643	18.947	31.151	45.411	61.895	80.730	102.222	126.506	153.609	183.791	217.285	254.529	295.711
1600	7.882	0	9.835	21.529	35.233	51.232	69.536	90.247	114.244	140.814	170.464	203.388	240.094	280.785
1700	16.483	9.054	0	11.214	24.364	39.740	57.470	77.852	101.022	127.025	156.095	188.453	224.590	264.689
1800	25.719	18.897	10.332	0	12.645	27.410	44.519	64.289	86.845	112.220	140.673	172.448	207.971	247.429
1900	35.618	29.449	21.537	11.748	0	14.193	30.649	49.759	71.651	96.363	124.162	155.277	190.136	228.934
2000	46.213	40.743	33.528	24.429	13.287	0	15.814	34.211	55.399	79.409	106.500	136.903	171.057	209.148
2100	57.547	52.825	46.349	37.991	27.587	14.973	0	17.675	38.105	61.364	87.698	117.349	150.754	188.094
2200	69.794	65.779	60.103	52.537	42.929	31.105	16.896	0	19.668	42.122	67.663	96.515	129.116	165.646
2300	82.729	79.660	74.842	68.129	59.363	48.379	35.010	18.790	0	21.694	46.385	74.386	106.133	141.816
2400	96.663	94.509	90.595	84.788	76.923	66.843	54.360	39.027	20.941	0	23.934	51.038	81.827	116.673
2500	111.575	110.396	107.451	102.612	95.711	86.586	75.064	60.664	43.372	23.380	0	26.341	56.238	90.074
2600	127.542	127.403	125.499	121.692	115.823	107.723	97.217	83.839	67.776	48.489	25.971	0	29.108	61.938
2700	144.649	145.631	144.841	142.136	137.366	130.355	120.936	108.638	93.640	75.409	53.937	28.814	0	31.990
2800	163.013	165.191	165.588	164.064	160.320	154.601	146.366	135.215	121.368	104.308	83.905	59.883	31.949	0

ORDINATES OF TRAJECTORY—Above and below line of sight

Alt.	100	200	300	400	500	600	700	800	900	1000	1100	1200	1300	1400	1500	1600
100	0	.16	.51	1.09	1.96	3.2	4.8	6.96	9.76	13.29	17.66	23.14	29.35	36.85	45.3	55.63
200	.68	0	.27	.77	1.56	2.7	4.26	6.33	9.05	12.5	16.8	22.2	28.33	35.75	44.16	54.37
300	1.7	.18	0	.41	1.11	2.16	3.63	5.41	8.23	11.5	15.8	21.11	27.15	34.43	42.8	52.92
400	3.1	.59	.31	0	.59	1.54	2.90	4.78	7.51	10.57	14.66	19.37	25.81	33.04	41.26	51.28
500	4.8	.82	.67	.47	0	.82	2.07	3.84	6.25	9.39	13.37	18.46	24.23	31.39	39.49	49.72
600	6.3	.9	1.03	1.02	.69	0	1.11	2.74	5.01	8.02	11.83	16.81	22.5	29.47	37.43	47.2
700	7.6	1.22	1.55	1.66	1.45	.95	0	1.48	3.59	6.44	10.12	14.91	20.45	27.25	35.06	44.6
800	8.7	1.6	2.1	2.4	2.34	2.06	1.29	0	1.83	4.59	8.09	12.7	18.04	24.66	32.28	41.71
900	10.3	2.02	2.75	3.25	3.47	3.34	2.78	1.7	0	2.45	5.74	10.13	15.26	21.67	29.03	38.29
1000	12.3	2.5	3.48	4.23	4.7	4.8	4.498	3.67	2.262	0	3.06	7.19	12.08	18.24	25.4	34.37
1100	14.69	3.059	4.316	5.34	6.081	6.471	6.439	5.884	4.69	2.771	0	3.87	8.47	14.36	21.24	29.93
1200	17.19	3.679	5.245	6.58	7.63	8.33	8.608	8.363	7.485	5.869	3.407	0	4.45	10.02	16.59	24.98
1300	20.26	4.362	6.271	7.948	9.34	10.382	11.001	11.098	10.562	9.287	7.165	4.1	0	5.24	11.46	19.5
1400	23.63	5.111	7.394	9.445	11.211	12.626	13.62	14.09	13.927	13.026	11.279	8.586	4.859	0	6.09	13.52
1500	27.012	5.925	8.616	11.072	13.245	15.067	16.47	17.343	17.58	17.091	15.749	13.461	10.138	5.68	0	7.02
1600	30.481	6.803	9.931	12.828	15.439	17.7	19.538	20.853	21.535	21.478	20.574	18.724	15.839	11.822	6.577	0
1700	34.954	7.748	11.349	14.719	17.803	20.53	22.837	24.634	25.787	26.202	25.77	24.4	21.97	18.4	13.3	7.5
1800	4.46	8.76	12.9	16.74	20.34	23.6	26.4	28.7	30.35	31.26	31.34	30.46	28.55	25.51	21.24	15.63
1900	5.0	9.85	14.5	18.9	23.05	26.8	30.19	33.02	35.22	36.7	37.22	36.9	35.6	33.08	29.35	24.28
2000	5.58	11.0	16.23	21.23	25.9	30.29	34.2	37.6	40.4	42.5	43.65	43.9	43.09	41.16	38.0	33.5
2100	6.198	12.23	18.08	23.7	29.02	33.99	38.5	42.58	45.97	48.6	50.4	51.28	51.09	49.8	47.22	43.3
2200	6.85	13.55	20.05	26.32	32.3	37.9	43.15	47.8	51.9	55.18	57.6	59.14	59.6	58.9	57.04	53.8
2300	7.55	14.95	22.15	29.12	35.8	42.13	48.04	53.4	58.16	62.16	65.3	67.5	68.7	67.49	64.9	64.9
2400	8.3	16.32	24.38	32.09	39.5	46.56	53.2	59.32	66.7	69.7	73.5	76.4	78.3	79.07	78.6	76.9
2500	9.09	18.02	26.76	35.26	41.5	51.3	58.8	65.7	71.96	77.5	82.17	85.9	88.6	90.1	90.4	89.4
2600	9.93	19.71	29.29	38.6	47.7	56.4	64.7	72.4	79.5	85.9	91.41	95.97	99.49	101.86	102.99	102.73
2700	10.83	21.5	31.98	42.22	52.17	61.8	70.95	79.6	87.6	94.86	101.26	106.7	111.1	114.36	116.37	117.04
2800	11.79	23.42	34.85	46.05	56.96	67.5	77.6	87.2	96.19	104.39	111.74	118.1	123.47	127.67	130.62	132.23
2900	12.84	25.46	37.91	50.12	62.05	73.6	84.8	95.4	105.3	114.56	122.92	130.3	136.66	141.86	145.81	148.4
3000	13.9	27.6	41.17	54.47	67.5	80.15	92.37	104.07	115.1	125.4	134.8	143.3	150.73	157.0	162.0	165.66
3100	15.06	29.96	44.66	59.13	73.3	87.12	100.5	113.35	125.55	137.0	147.58	157.2	165.76	173.16	179.3	184.09

Minus ordinates above zero in bold type; plus ordinates below zero in light type.

ORDINATES OF TRAJECTORY--Above and below line of sight

Horizontal distance

Yards

Yds	1700	1800	1900	2000	2100	2200	2300	2400	2500	2600	2700	2800	2900	3000	3100
100	67.14	80.2	94.95	111.49	129.97	150.45	173.3	193.41	225.8	256.14	289.1	324.92	364.12	406.87	453.32
200	65.8	78.78	93.45	109.91	128.32	148.81	171.49	196.52	223.8	254.09	286.97	322.71	361.83	404.5	450.87
300	64.26	77.15	91.73	108.1	126.41	146.82	169.41	194.34	221.57	251.73	284.52	320.18	359.21	401.79	448.06
400	62.51	75.3	89.77	106.04	124.25	144.55	167.04	191.37	218.99	249.05	281.75	317.3	356.22	398.7	444.87
500	60.5	73.17	87.52	103.68	121.78	141.96	164.32	189.04	216.25	245.99	278.56	313.99	352.8	395.16	441.22
600	58.18	70.70	84.92	100.94	118.9	138.95	161.17	185.75	212.82	242.43	274.86	310.16	348.83	391.05	436.97
700	55.49	67.86	81.92	97.95	115.58	135.47	157.54	181.96	208.87	233.32	270.59	305.73	344.25	386.31	433.07
800	52.34	64.5	78.4	94.08	111.7	131.4	153.29	177.52	204.25	233.51	265.6	300.55	338.88	380.76	426.34
900	48.7	60.68	74.34	89.8	107.2	126.69	148.4	172.38	198.9	227.95	259.82	294.55	332.67	374.34	419.71
1000	44.54	56.27	69.69	84.9	102.05	121.3	142.73	166.5	192.77	221.58	253.2	287.7	325.57	366.99	412.11
1100	39.83	51.28	64.42	79.36	96.25	115.21	136.36	159.86	185.85	214.37	245.73	279.94	317.54	358.68	403.53
1200	34.56	45.7	58.53	73.16	89.74	108.39	129.23	152.41	178.09	206.32	237.35	271.26	308.55	349.38	393.91
1300	28.74	39.54	52.04	66.32	82.55	100.87	121.36	144.21	169.54	197.42	228.12	261.68	298.63	339.12	383.31
1400	22.39	32.81	44.93	58.84	74.7	92.64	112.76	135.23	160.2	187.7	218.03	251.21	287.78	327.9	371.72
1500	15.49	25.5	37.22	50.72	66.17	83.7	103.43	125.49	150.05	177.14	207.06	239.85	276.01	315.72	359.10
1600	8.02	17.6	28.87	41.94	56.95	74.05	93.33	114.95	139.07	165.73	195.21	227.55	263.23	302.55	345.53
1700	0	9.1	19.91	32.5	47.04	63.66	82.47	103.62	127.27	153.45	182.5	214.3	249.6	288.39	330.89
1800	8.59	0	10.3	22.38	36.41	52.53	70.84	91.48	114.62	140.3	168.8	200.17	234.72	273.21	315.21
1900	17.77	9.72	0	11.54	25.03	40.61	58.37	78.47	101.07	126.21	154.17	184.99	219.21	256.95	298.41
2000	27.6	20.08	10.9	0	12.91	27.92	45.1	64.63	86.65	111.2	138.59	168.83	202.47	239.64	280.52
2100	38.01	31.13	22.6	12.26	0	14.38	30.96	49.87	71.27	95.21	121.98	151.62	184.64	221.19	261.46
2200	49.12	42.89	34.99	25.3	13.7	0	15.92	34.17	54.92	78.21	104.33	133.30	165.67	201.57	241.18
2300	60.9	55.4	48.18	39.18	28.24	15.23	0	17.57	37.62	60.22	85.64	113.92	145.60	180.81	219.73
2400	73.5	68.7	62.21	53.9	43.7	31.43	16.9	0	19.32	41.18	65.88	93.43	124.38	158.85	197.03
2500	86.9	82.8	77.1	69.6	60.2	48.65	34.9	18.6	0	21.08	45.01	71.79	101.96	135.66	173.07
2600	101.12	97.9	93.0	86.31	77.67	66.96	54.0	38.51	20.71	0	23.11	49.08	78.44	111.33	147.93
2700	116.26	113.9	109.88	104.06	96.28	86.42	74.33	59.7	42.24	22.86	0	25.12	53.62	85.65	121.4
2800	132.39	130.95	127.85	122.94	116.09	107.15	95.96	82.21	66.16	47.17	25.2	0	27.61	58.74	93.59
2900	149.54	149.11	147.0	143.07	137.19	129.21	118.99	106.2	91.09	72.9	52.01	27.74	0	30.18	64.08
3000	167.86	168.49	167.4	164.51	159.67	152.72	143.52	131.75	117.65	100.61	80.56	57.27	30.5	0	32.89
3100	187.41	189.15	189.19	187.41	183.33	177.81	169.7	159.0	145.97	129.99	111.0	88.75	63.0	33.52	0

Minus ordinates above zero in bold type; plus ordinates below zero in light face type.

RANGE TABLE—Vickers Machine Gun—Mark IV Tripod—1960 Ammunition

Range Meters	Angle of Departure			Angle of Fall			Summit Height. Distance		Lowest Shot Below Mean Traj. Meters.	Prob. Error (½ 50 Pct.)			Time of Flight Seconds	Penetrating Velocity Meter per Sec.	Range Error Meters	Deaden Zone Depth in Meters	
	Deg.	Min.	Mils.	Deg.	Min.	Mils.	Meters.	Meters.		Vert.	Hor.	Right				50 Pct.	100 Pct.
100	0	2.679	.779	0	2.880	.838	.0219	51.07	.28				0.129	745.29	1.9	225	651
200		5.737	1.669		6.604	1.921	.0935	104.11	.57				.259	622.52	2.99	193	550
300		9.274	2.698		11.456	3.333	.2303	158.01	.85	.17	.08		.479	603.69	3.74	156	475
400		13.361	3.887		17.747	5.164	.4546	213.86	1.1	.225	.12		.745	542.32	4.4	111	408
500		18.133	5.276		25.914	7.540	.7821	272.60	1.4	.285	.15		.797	485.29	4.79	118	349
600		23.713	6.899		36.445	10.604	1.2902	332.34	1.7	.35	.18		1.015	431.73	4.42	103	297
700		30.256	8.803		49.921	14.525	1.9841	393.88	2.3	.41	.21		1.259	380.36	3.69	88.5	252
800		37.940	11.039	1	6.727	19.414	2.9388	457.25	2.6	.47	.24	.1	1.528	335.46	2.91	75.6	216
900		46.872	13.637		26.697	25.225	4.2146	521.67	2.8	.535	.26	.16	1.818	325.16	2.939	67.9	192
1000		57.118	16.619		49.557	31.876	5.8545	584.81	3.2	.57	.29	.25	2.230	309.96	2.57	62.6	176
1100	1	8.727	19.993	2	15.063	39.297	7.942	647.76	3.6	.63	.33	.35	2.462	294.14	2.11	54.1	163
1200		21.715	23.775		43.169	47.474	10.501	708.33	4.2	.69	.36	.5	2.810	280.54	1.66	51.1	154
1300		36.014	27.935	3	13.916	56.420	13.575	767.60	5	.76	.41	.5	3.180	268.29	1.25	48.4	149
1400		51.634	32.480		47.433	66.172	17.206	825.97	5.6	.81	.46	.6	3.561	257.03	0.8	51.8	147
1500	2	8.597	37.415	4	23.835	76.763	21.465	882.21	6.0	1.1	.50	.7	3.960	246.80	0.74	52.2	145
1600		26.931	42.750	5	3.343	88.258	26.306	941.45	7.7	1.2	.56	.76	4.376	237.42	0.69	53.9	146
1700		46.672	48.493		46.189	100.724	31.878	998.24	8.8	1.3	.63	.85	4.807	228.5	0.62	54.3	143
1800	3	7.859	54.658	6	32.616	114.232	38.209	1057.18	10.4	1.4	.78	.95	5.258	219.9	0.49	55.9	140
1900		30.563	61.264	7	23.038	128.903	45.379	1115.75	12.4	1.6	.95	1.1	5.726	211.7	22.33	57.1	131
2000		54.864	68.334	8	17.715	144.811	53.470	1174.78	14.7	1.8	1.1	1.3	6.214	203.84	26.71	58.2	124
2100	4	20.841	75.892	9	17.079	162.083	61.973	1234.75	17.4	2.0	1.3	1.5	6.722	196.40	19.20	62.2	112
2200		48.692	83.995	10	21.979	180.966	72.638	1295.03	21.4	2.3	1.5	1.7	7.207	189.3	17.85	67.3	101
2300	5	18.516	92.673	11	32.032	201.348	84.370	1356.04	26.2	2.7	1.8	2.0	7.807	182.56	16.61	73.8	90
2400		50.354	101.936	12	48.210	223.512	97.273	1417.69	32.2	3.1	2.1	2.3	8.384	176.17	15.47	80.8	79
2500	6	24.370	111.833	14	10.685	247.508	111.677	1480.03	39.5	3.6	2.4	2.6	8.987	170.19	14.44	89.2	70
2600	7	.835	122.443	15	40.282	273.576	127.75	1543.07	47.2	4.1	2.7	2.9	9.617	164.55	13.50	97.8	60
2700		39.790	133.777	17	16.563	301.589	145.69	1606.92	56	4.7	3.0	3.2	10.276	159.11	12.62	107.	50
2800	8	21.495	145.911	18	12.791	317.949	165.70	1671.45	65	5.3	3.3	3.5	10.965	154.3	11.86	117.	40
2900	9	7.534	159.306	20	51.241	364.050	186.03	1743.05	76	6.0	3.7	3.9	11.713	150.97	11.32	127.	30
3000		58.784	174.217	23	2.152	402.139	206.46	1819.61	90	7.0	4.1	4.3	12.53	148.3	10.9	138.	20
3100	10	54.883	190.539	25	21.306	442.626	228.42	1897.41	107	8.1	4.5	4.7	13.29	145.9	10.56		
3200	11	54.736	207.953	27	52.333	486.568	253.12	1975.42	126	9.3	5.0	5.2	14.10	143.64	10.22		
3300	13	1.683	227.432	30	36.119	534.221	281.48	2053.48	147	10.6	5.5	5.7	14.93	141.3	9.90		
3400	14	12.403	248.008	33	31.926	585.373	314.7	2132.48	170	12.1	6.0	6.2	15.79	139.32	9.62		
3500	15	27.872	269.966	36	39.400	639.919	352.8	2211.71	200	14.0	6.8	7.0	16.68	141.65	9.36		
3600	16	48.459	293.413	39	58.854	697.950	399.8	2291.71	235	16.3	7.5	7.7	17.60	136.21	9.20		
3700	18	15.446	318.722	43	57.042	767.251	456.5	2371.71	280	19.0	8.3	8.5	18.61	128.64	9.05		
3800	19	51.226	346.589	47	54.667	836.388	532.4	2452.20	330	22.0	9.3	9.5	19.6	126.2	9.19		
3900	22	18.666	389.487	51	42.291	902.616	673.0	2534.23	390	25.5	10.5	10.7	20.78	126.14	9.46		
4000	28	15.832	493.405	58	4.000	1013.675	931.3	2630.17	460	30.0	12.0	12.2	22.11	111.88	10.41		

TABLE FOR USE IN SEARCHING REVERSE SLOPES
(All figures in Meters)

1	2	3	4	5	6	7	8	9	10	11	12	Gun Above or Below Crest	12	11	10	9	8	7	6	5	4	3	2	1
1450	1600	1650	1700	1750	1750	1900	2000	2100	2100	2150	2200		1950	1900	1800	1750	1650	1550	1500	1350	1250	1200	1150	1100
1250	1400	1500	1550	1650	1700	1800	1850	1950	2000	2050	2100	0	2100	2050	2000	1950	1850	1800	1700	1650	1550	1500	1400	1250
1350	1450	1550	1600	1700	1750	1800	1900	1950	2000	2100	2150	10	2050	2000	1950	1900	1800	1750	1700	1600	1500	1400	1300	1200
1450	1500	1600	1700	1750	1800	1850	1950	2000	2050	2100	2150	20	2050	2000	1900	1850	1800	1700	1650	1550	1450	1350	1200	1100
1500	1600	1650	1750	1800	1850	1900	1950	2050	2050	2150	2200	30	2000	1950	1900	1850	1750	1650	1600	1500	1400	1250	1150	1000
1600	1650	1700	1750	1800	1900	1950	2000	2050	2100	2150	2200	40	2000	1950	1850	1800	1700	1600	1550	1450	1300	1200	1050	
1650	1700	1750	1800	1850	1900	2000	2050	2100	2150	2200	2250	50	2000	1900	1850	1750	1650	1600	1500	1350	1250	1100		
1700	1750	1800	1850	1900	1950	2000	2050	2100	2150	2200	2250	60	1950	1850	1800	1700	1650	1550	1450	1300	1200	1000		
1750	1800	1850	1900	1950	2000	2050	2100	2150	2200	2250	2300	70	1900	1850	1750	1700	1600	1500	1400	1250	1100			
1800	1850	1900	1950	2000	2000	2100	2150	2150	2200	2250	2300	80	1900	1800	1700	1650	1550	1450	1300	1200	1000			
1900	1900	1950	2000	2000	2050	2100	2150	2200	2250	2300	2300	90	1850	1750	1700	1600	1500	1400	1250	1100				
1950	1950	2000	2000	2050	2100	2150	2200	2200	2250	2300	2350	100	1800	1750	1650	1550	1450	1300	1200	1000				
2000	2000	2000	2050	2100	2150	2150	2200	2250	2300	2350	2350	110	1800	1700	1600	1500	1400	1250	1100					
2050	2000	2050	2100	2100	2150	2200	2250	2250	2300	2350	2400	120	1750	1650	1550	1450	1350	1200	1050					
2050	2050	2100	2150	2150	2200	2200	2250	2300	2350	2350	2400	130	1700	1600	1500	1400	1300	1100						
2100	2100	2150	2150	2200	2200	2250	2300	2300	2350	2400	2450	140	1700	1600	1450	1350	1200	1050						
2150	2150	2200	2200	2200	2250	2250	2300	2350	2400	2400	2450	150	1650	1550	1400	1300	1150	1000						
2200	2200	2200	2250	2250	2300	2300	2350	2350	2400	2450	2450	160	1600	1500	1400	1250	1100							
2250	2200	2250	2250	2300	2300	2300	2350	2400	2400	2450	2500	170	1550	1450	1350	1200	1000							
2300	2250	2250	2300	2300	2350	2350	2400	2400	2450	2450	2500	180	1500	1400	1300	1100								
2350	2300	2300	2300	2350	2350	2400	2400	2450	2450	2500	2550	190	1450	1350	1250	1050								
2350	2300	2300	2350	2350	2400	2400	2450	2450	2500	2500	2550	200	1400	1300	1200	1000								

Gun Below Crest

Gun Above Crest

1. The top horizontal line is the drop in meters in the first 100 meters beyond the crest. The horizontal line directly below it is the distance to measure back from the crest to find gun position.

2. Explanation of use of table.

Example: The ground drops 7 meters in 100; assume also that the gun is below the crest. The left-hand side of table must therefore be used. The table shows that for a drop of 7 meters we must go back 1900 meters from the crest. At this point, say, the gun position is found to be 90 meters below the crest. Final range, therefore, equals 2100 meters. Place the gun at this point.

3. Searching should be employed away from the crest, but it must be remembered that as the cone strikes falling ground the length of zone will be very much increased, therefore, the turns of the handwheel should be few in number.

4. If the final position is not suitable the gun should be moved farther away from, not nearer to, the crest; the elevation should be increased by the distance moved.

5. If it be desired to engage an area of ground which lies some distance back from the crest, without searching back from the crest itself, the position of the gun must be determined with reference to the crest as detailed above. Then the quadrant elevation necessary to hit the near limit of the ground to be searched must be applied in the usual way for indirect fire.

Target Above Gun.

QUADRANT ANGLE IN MILS, KNOWING RANGE AND V. I.—(Both in Meters)

V.I	100	200	300	400	500	600	700	800	900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300	2400	2500	2600	2700	2800	2900	3000
1	10.	5.	3.3	2.5	2.	1.6	1.4	1.2	1.1	1.	.9	.8	.75	.7	.65	.6	.55	.5	.5	.45	.45	.4	.4	.4	.4	.35	.35	.35	.35	.3
5	50.8	26.7	19.4	16.4	15.3	15.2	15.9	17.3	19.20	21.6	24.5	27.9	31.8	36.	40.7	45.9	51.4	57.4	63.9	70.8	78.3	86.3	94.8	104.	113.8	124.4	135.6	147.7	161.	175.9
10	100.8	51.7	36.	28.9	25.3	23.5	23.	23.5	24.75	26.6	29.1	32.1	35.6	39.6	44.1	49.	54.4	60.2	66.5	73.3	80.6	88.5	97.0	106.1	115.8	126.3	137.5	149.5	162.7	177.5
15	150.8	76.6	52.7	41.4	35.3	31.8	30.1	29.8	30.3	31.6	33.6	36.3	39.5	43.2	47.4	52.1	57.3	63.	69.1	75.8	83.	90.8	99.2	108.2	117.8	128.2	139.3	151.3	164.5	179.2
20	200.8	101.7	69.4	53.9	45.3	40.1	37.2	36.	35.8	36.6	38.2	40.4	43.3	46.8	50.7	55.2	60.2	65.8	71.8	78.3	85.4	93.1	101.4	110.3	119.8	130.1	141.2	153.	166.2	180.9
25	250.8	126.7	86.	66.4	55.3	48.4	44.3	42.3	41.4	41.6	42.7	44.6	47.2	50.3	54.1	58.3	63.2	68.5	74.4	80.8	87.8	95.3	103.5	112.3	121.8	132.	143.	154.8	167.9	182.5
30	-----	151.7	102.7	78.9	65.3	56.7	51.5	48.5	47.	46.6	47.3	48.8	51.	53.9	57.4	61.5	66.1	71.3	77.	83.3	90.2	97.6	105.7	114.4	123.8	134.	144.9	156.6	169.6	184.2
35	-----	176.7	119.4	91.4	75.3	65.	58.6	54.8	52.5	51.6	51.8	53.	54.8	57.5	60.7	64.4	69.1	74.1	79.7	85.8	92.5	99.9	107.9	116.5	125.8	135.9	146.7	158.4	171.4	185.9
40	-----	201.7	136.	103.9	85.3	73.3	65.7	61.	58.1	56.6	56.3	57.1	58.7	61.	64.1	67.7	72.	76.9	82.3	88.3	94.9	102.2	110.1	118.6	127.8	137.8	148.6	160.2	173.1	187.5
45	-----	226.7	152.7	116.4	95.3	81.6	72.9	67.3	63.6	61.5	60.9	61.3	62.5	64.5	67.4	70.1	74.9	79.7	84.9	90.8	97.3	104.4	112.2	120.7	129.8	139.7	150.4	162.	174.8	189.2
50	-----	251.7	169.4	128.9	105.3	89.9	80.	73.5	69.2	66.6	65.4	65.5	66.4	68.2	70.7	73.9	77.9	82.4	87.6	93.3	99.7	106.7	114.4	122.8	131.8	141.7	152.3	163.7	176.5	190.9
55	-----	-----	186.	141.4	115.3	98.2	87.1	79.8	74.7	71.6	70.	69.6	70.2	71.7	74.1	77.1	80.8	85.2	90.2	95.8	102.1	109.	116.6	124.8	133.8	143.6	154.1	165.5	178.3	192.5
60	-----	-----	202.7	153.9	125.3	106.5	94.3	86.	80.3	76.6	74.5	73.8	74.1	75.3	77.4	80.2	83.8	88.	92.8	98.3	104.5	111.2	118.8	126.9	135.8	145.5	156.	167.3	180.	194.2
65	-----	-----	219.4	166.4	135.3	114.8	101.4	92.3	85.8	81.6	79.1	78.	77.9	78.9	80.7	83.3	86.7	90.8	95.5	100.8	106.8	113.5	120.9	129.	137.8	147.4	157.8	169.1	181.7	195.9
70	-----	-----	236.	178.9	145.3	123.1	108.5	98.5	91.4	86.6	83.6	82.1	81.8	82.5	84.1	86.4	89.6	93.5	98.1	103.3	109.2	115.8	123.1	131.1	139.8	149.4	159.7	170.9	183.4	197.5
75	-----	-----	-----	191.4	155.3	131.4	115.7	104.8	97.	91.6	88.2	86.3	85.6	86.	87.4	89.5	92.6	96.3	100.7	105.8	111.6	118.1	125.3	133.2	141.8	151.3	161.5	172.7	185.2	199.2
80	-----	-----	-----	203.9	165.3	139.7	122.8	111.	102.5	96.6	92.7	90.5	89.5	89.5	90.7	92.7	95.5	99.1	103.4	108.3	114.	120.3	127.4	135.3	143.8	153.2	163.4	174.5	186.9	200.9
85	-----	-----	-----	216.4	175.3	148.	129.9	117.3	108.1	101.6	97.3	94.7	93.3	93.2	94.1	95.8	98.5	101.9	106.	110.8	116.4	122.6	129.6	137.3	145.8	155.1	165.2	176.2	188.6	202.5
90	-----	-----	-----	228.9	185.3	156.3	137.1	123.5	113.6	106.6	101.8	98.8	97.2	96.7	97.4	98.9	101.4	104.7	108.6	113.3	118.7	124.9	131.8	139.4	147.8	157.	167.1	178.	190.3	204.2
95	-----	-----	-----	241.4	195.3	164.6	144.2	129.8	119.2	111.6	106.3	103.	101.	100.8	100.7	102.	104.3	107.4	111.2	115.8	121.1	127.2	134.	141.5	149.8	159.	168.9	179.8	192.1	205.9
100	-----	-----	-----	-----	205.3	172.9	151.3	136.	124.7	116.6	110.9	107.2	104.8	103.9	104.1	105.1	107.3	110.2	113.9	118.3	123.5	129.4	136.1	143.6	151.8	160.9	170.8	181.6	193.8	207.5
110	-----	-----	-----	-----	225.3	189.5	165.6	148.5	135.8	126.6	120.	115.5	112.4	111.	110.7	111.3	113.2	115.7	119.2	123.3	128.3	133.9	140.5	147.8	155.8	164.7	174.5	185.2	197.2	210.9
120	-----	-----	-----	-----	245.3	206.1	179.8	161.	146.9	136.6	129.	123.9	120.1	118.2	117.4	117.6	119.1	121.3	124.4	128.3	133.	138.5	144.8	151.9	159.8	168.6	178.2	188.7	200.7	214.2
130	-----	-----	-----	-----	265.3	222.7	194.1	173.5	158.	146.6	138.2	132.2	127.7	125.5	124.1	123.8	124.9	126.8	129.7	133.3	137.8	143.	149.2	156.1	163.8	172.4	181.9	192.3	204.1	217.5
140	-----	-----	-----	-----	285.3	239.3	208.4	186.	169.1	156.6	147.3	140.5	135.4	132.5	130.7	130.1	130.8	132.4	134.9	138.3	142.5	147.6	153.5	160.3	167.8	176.3	185.6	195.9	207.6	220.9
150	-----	-----	-----	-----	305.3	255.9	222.7	198.5	180.2	166.6	156.3	148.8	143.	139.6	137.4	136.3	136.7	137.9	140.2	143.3	147.3	152.1	157.9	164.4	171.8	180.1	189.3	199.5	211.	224.2
160	-----	-----	-----	-----	325.3	272.5	237.	211.	191.3	176.6	165.4	157.2	150.7	146.7	144.1	142.6	142.6	143.4	145.5	148.3	152.1	156.7	162.2	168.6	175.8	184.	193.	203.	214.5	227.5
170	-----	-----	-----	-----	345.3	289.1	251.2	223.5	202.4	186.6	174.5	165.5	158.3	153.9	150.7	148.8	148.5	149.	150.7	153.3	156.8	161.2	166.6	172.7	179.8	187.8	196.7	206.6	217.9	230.9
180	-----	-----	-----	-----	365.3	305.7	265.5	236.	213.5	196.6	183.6	173.8	166.	161.	157.4	155.1	154.3	154.5	156.	158.8	161.6	165.7	170.9	176.9	183.8	191.7	200.4	210.1	221.4	234.2
190	-----	-----	-----	-----	385.3	322.3	279.8	248.5	224.6	206.6	192.7	182.2	173.6	168.2	164.	161.3	160.2	160.1	161.2	163.3	166.3	170.3	175.3	181.1	187.8	195.5	204.1	213.7	224.8	237.5
200	-----	-----	-----	-----	405.3	338.9	293.1	261.	235.7	216.6	201.8	190.6	181.2	175.4	170.6	167.5	166.1	165.6	166.4	167.5	170.7	174.6	179.4	185.2	191.8	199.3	207.9	217.3	228.2	240.8

ABOVE GUN

1. This table combines the angle of site with the angle of tangent elevation, thus producing the quadrant angle directly.
2. It is used as follows: Range 1900 meters; Target 55 meters above gun. Quadrant Elevation = 90.2 mils.
3. The top line where V. I. = 1 meter is used for interpolation between 5 meter differences in elevation. Example: Range 2200 meters; Target 72 meters above gun. Quadrant Elevation for 2200 meters with V. I. 70 meters = 115.8; at this range .45 mils must be added for each additional meter; the Quadrant Elevation will therefore be $115.8 + (2 \times .45) = 116.7$ mils.

Target Below Gun.

QUADRANT ANGLE IN MILLS. KNOWING RANGE AND V. I.—(Both in Meters)

V. I.	100	200	300	400	500	600	700	800	900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300	2400	2500	2600	2700	2800	2900	3000
1	10.	5.	3.3	2.5	2.	1.6	1.4	1.2	1.1	1.	.9	.8	.75	.7	.65	.6	.6	.55	.5	.5	.45	.45	.4	.4	.4	.4	.35	.35	.35	.3
5	49.2	23.3	14.	8.6	4.7	1.4	1.7	4.8	8.1	11.6	15.4	19.6	24.1	28.9	34.1	39.6	45.5	51.9	58.6	65.8	73.5	81.7	90.5	99.8	109.8	120.5	131.9	144.1	157.6	172.5
10	99.2	48.3	30.6	21.1	14.7	9.8	5.48	1.5	2.5	6.6	10.9	15.4	20.2	25.3	30.7	36.5	42.6	49.1	56.	63.3	71.1	79.4	88.3	97.8	107.8	118.6	130.1	142.3	155.8	170.9
15	149.2	73.3	47.3	33.6	24.7	18.1	12.6	7.7	3.	1.6	6.4	11.3	16.4	21.8	27.4	33.4	39.7	46.3	53.4	60.8	68.7	77.2	86.1	95.7	105.8	116.7	128.2	140.5	154.1	169.2
20	199.2	98.3	64.	46.1	34.7	26.4	19.8	14.	8.6	3.4	1.8	7.1	12.5	18.2	24.1	30.2	36.7	43.5	50.7	58.3	66.4	74.9	84.	93.6	103.8	114.7	126.4	138.8	152.4	167.5
25		123.3	80.1	58.6	44.7	34.7	26.9	20.2	14.1	8.4	2.7	2.9	8.7	14.6	20.7	27.1	33.8	40.8	48.1	55.8	64.	72.6	81.8	91.5	101.8	112.8	124.5	137.	150.7	165.9
30		148.3	97.3	71.1	54.7	43.1	34.	26.5	19.7	13.4	7.3	1.2	4.8	11.	17.4	24.	30.8	38.	45.5	53.3	61.6	70.3	79.6	89.4	99.8	110.9	122.7	135.2	149.	164.2
35		173.3	114.	83.6	64.7	51.4	41.2	32.7	25.2	18.4	11.8	5.4	1.	7.5	14.1	20.9	27.9	35.2	42.8	50.8	59.2	68.1	77.4	87.3	97.8	109.	120.8	133.4	147.2	162.5
40		198.3	130.1	96.1	74.7	59.8	48.3	39.	30.8	23.4	16.4	9.5	2.8	3.9	10.7	17.7	25.	32.4	40.2	48.3	56.8	65.8	75.3	85.3	95.8	107.	119.	131.6	145.5	160.9
45			147.3	108.6	84.7	68.1	55.5	45.2	36.4	28.4	20.9	13.7	6.7	3	7.4	14.6	22.	29.6	37.6	45.8	54.5	63.5	73.1	83.2	93.8	105.1	117.1	129.8	143.8	159.2
50			164.	121.1	94.7	76.4	62.6	51.5	41.9	33.4	25.4	17.9	10.5	3.2	4.1	11.5	19.1	26.9	34.9	43.3	52.1	61.3	70.9	81.1	91.8	103.2	115.2	128.	142.1	157.5
55			180.1	133.6	104.7	84.8	69.8	57.7	47.5	38.4	30.	22.	14.4	6.8	.7	8.4	16.1	24.1	32.3	40.8	49.7	59.	68.7	79.	89.8	101.3	113.4	126.3	140.3	155.9
60			197.3	146.1	114.7	93.1	76.9	64.	53.	43.4	34.5	26.2	18.2	10.4	2.6	5.2	13.2	21.3	29.7	38.3	47.3	56.7	66.6	76.9	87.8	99.4	111.5	124.5	138.6	154.2
65			214.	158.6	124.7	101.4	84.	70.2	58.6	48.4	39.1	30.4	22.1	13.9	5.9	2.1	10.2	18.5	27.	35.8	44.9	54.4	64.4	74.8	85.8	97.4	109.7	122.7	136.9	152.5
70				171.1	134.7	109.8	91.2	76.5	64.1	53.4	43.6	34.5	25.9	17.5	9.2	1.	7.3	15.8	24.4	33.3	42.5	52.2	62.2	72.8	83.8	95.5	107.8	120.9	135.2	150.9
75				183.6	144.7	118.1	98.3	82.7	69.7	58.4	48.2	38.7	29.7	21.1	12.6	4.1	4.4	13.	21.8	30.8	40.2	49.9	60.1	70.7	81.8	93.6	106.	119.1	133.4	149.2
80				196.1	154.7	126.4	105.5	89.	75.2	63.4	52.7	42.9	33.6	24.7	15.9	7.2	1.4	10.2	19.2	28.3	37.8	47.6	57.9	68.6	79.8	91.7	104.1	117.3	131.7	147.5
85				208.6	164.7	134.8	112.6	95.2	80.8	68.4	57.3	47.	37.4	28.2	19.2	10.4	1.5	7.4	16.5	25.8	35.4	45.4	55.7	66.5	77.8	89.7	102.3	115.5	130.	145.9
90				221.1	174.7	143.1	119.8	101.5	86.4	73.4	61.8	51.2	41.3	31.8	22.6	13.5	4.4	4.6	13.9	23.3	33.0	43.1	53.5	64.4	75.8	87.8	100.4	113.8	128.3	144.2
95				233.6	184.7	151.4	126.9	107.7	91.9	78.4	66.4	55.4	45.1	34.4	25.9	16.6	7.4	1.9	11.3	20.8	30.6	40.8	51.4	62.3	73.8	85.9	98.6	112.	126.5	142.5
100				246.1	194.7	159.8	134.	114.	97.5	83.4	70.9	59.5	49.	38.9	29.2	19.7	10.3	.9	8.6	18.3	28.3	38.5	49.2	60.3	71.8	84.	96.7	110.2	123.1	140.9
110				271.1	214.7	176.5	148.3	126.5	108.6	93.4	80.	67.9	56.7	46.1	35.9	26.	16.2	6.4	3.4	13.3	23.5	34.	44.8	56.1	67.8	80.1	93.	106.6	119.6	137.5
120				296.1	234.7	193.1	162.5	139.	119.7	103.4	89.1	76.2	64.4	53.2	42.6	32.2	22.1	12.	1.9	8.3	18.7	29.4	40.5	51.9	63.8	76.3	89.3	103.	116.2	134.2
130				321.1	254.7	209.8	176.8	151.5	130.8	113.4	98.2	84.5	72.1	60.4	49.2	38.5	28.	17.6	7.1	3.3	14.1	24.9	36.1	47.8	59.8	72.4	85.6	99.5	112.7	130.9
140				346.1	274.7	226.4	191.1	164.	141.9	123.4	107.3	92.9	79.7	67.5	55.9	44.7	33.8	23.1	12.4	1.7	9.2	20.4	31.8	43.6	55.8	68.6	81.9	95.9	109.3	127.5
150				371.1	294.7	243.1	205.4	176.5	153.	133.4	116.4	101.2	87.4	74.7	62.6	51.	39.7	28.7	17.7	6.7	4.5	15.8	27.4	39.4	51.8	64.7	78.2	92.3	105.8	124.2
160				396.1	314.7	259.8	219.7	189.	164.	143.4	125.4	109.5	95.1	81.8	69.2	57.2	45.6	34.2	22.9	11.7	.3	11.3	23.1	35.3	47.8	60.9	74.5	88.8	102.4	120.9
170				421.1	334.7	276.4	234.	201.5	175.	153.4	134.5	117.9	102.8	88.9	75.9	63.5	51.5	39.8	28.2	16.7	5.1	6.7	18.8	31.1	43.8	57.0	70.8	85.2	99.	117.5
180				446.1	354.7	293.1	248.3	214.	186.	163.4	143.6	126.2	110.5	96.1	82.6	69.7	57.4	45.3	33.5	21.7	9.8	2.2	14.4	26.9	39.8	53.2	67.1	81.6	95.5	142.2
190				471.1	374.7	309.7	262.5	226.5	197.5	173.4	152.7	134.5	118.2	103.2	89.2	76.	63.3	50.9	38.7	26.7	14.6	2.4	10.1	22.8	35.8	49.4	63.4	78.	92.1	110.9

BELOW GUN

Angles printed in bold type are minus angles.

1. This table combines the angle of site with the angle of tangent elevation, thus producing the quadrant angle directly.
 2. It is used as follows: Range = 1900 meters; Target 55 meters below gun. Quadrant Elevation = 32.3 mils.
 3. The top line where V. I. = 1 meter is used for interpolation between 5 meter differences in elevation. Example I: Range 2200 meters; Target 72 meters below gun. Quadrant Elevation = 52.2 mils with V. I. 70 meters = 52.2; at this range .45 mils must be deducted for each additional meter; the Quadrant Elevation will therefore be 52.2—(2×.45) = 51.3 mils. Example II: Range 1300 meters; Target 38 meters below gun = 1.—(3×.75 = minus 1.25 mils. Example III: Range 800 meters; Target 28 meters below gun = minus 20.2—(3×1.2 = minus 23.8 mils.

ORDINATES OF NEGATIVE QUADRANT ELEVATION

Q. E. Mils.	METERS																		
	500	600	700	800	900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	
—1.	.5	.6	.715	.8	.9	1.	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.95	2.	2.1	2.2	
—5	5.	7.25	9.7	12.8	16.9	21.6	27.5	34.5	43.	52.5	63.6	76.5	91.	107.5	126.2	146.6	169.8	195.7	
—10	7.5	10.25	13.2	16.8	21.3	26.6	33.	40.5	49.4	59.5	71.2	84.5	99.5	116.4	135.8	156.6	180.4	207.	
—15	10.	13.25	16.8	20.8	25.9	31.6	38.5	46.5	55.8	66.5	78.7	92.5	108.	125.4	145.2	166.6	191.	218.7	
—20	12.5	16.25	20.3	24.8	30.3	36.6	44.	52.5	62.4	73.5	86.2	100.5	116.5	134.3	154.6	176.6	201.4	230.	
—25	15.	19.25	23.8	28.8	34.8	41.6	49.5	58.5	68.8	80.5	93.7	108.5	125.	143.3	164.2	186.6	211.8	241.7	
—30	17.5	22.25	27.3	32.8	39.3	46.6	55.	64.5	75.4	87.5	101.2	116.5	133.5	152.3	173.6	196.6	222.2	253.	
—35	20.	25.25	30.8	36.8	43.8	51.6	60.5	70.5	81.8	94.5	108.7	124.5	142.	161.4	183.	206.6	232.7	264.7	
—40	22.5	28.25	34.3	40.8	48.3	56.6	66.	76.5	88.4	101.5	116.2	132.5	150.5	170.4	192.6	216.6	243.1	276.	
—45	25.	31.25	37.8	44.8	52.8	61.6	71.5	82.5	94.8	108.5	123.7	140.5	159.	179.3	201.2	226.6	253.5	287.7	
—50	27.5	34.25	41.3	48.8	57.3	66.6	77.	88.5	101.4	115.5	131.2	148.5	167.5	188.3	210.6	236.6	264.	299.	
—55	30.	37.25	44.8	52.8	61.8	71.6	82.5	94.5	107.8	122.5	138.7	156.5	176.	197.3	219.6	246.6	274.4	310.7	
—60	32.5	40.25	48.3	56.8	66.3	76.6	88.	100.5	114.4	129.5	146.2	164.5	184.5	206.4	228.2	256.6	284.8	322.	
—65	35.	43.25	51.8	60.8	70.9	81.6	93.5	106.5	120.8	136.5	153.7	172.5	193.	215.4	237.6	266.6	295.2	333.7	
—70	37.5	46.25	55.3	64.8	75.3	86.6	99.	112.5	127.4	143.5	161.2	180.5	201.5	224.3	246.6	276.6	305.7	345.	
—75	40.	49.25	58.8	68.8	79.8	91.6	104.5	118.5	133.8	150.5	168.7	188.5	210.	233.3	255.2				
—80	42.5	52.25	62.3	72.8	84.3	96.6	110.	124.5	140.4	157.5	176.2	196.5	218.5						
—85	45.	55.25	65.7	76.8	88.8	101.6	115.5	130.5	146.8	164.5	183.7	204.5	227.						
—90	47.5	58.25	69.2	80.8	93.3	106.6	121.	136.5	153.4	171.5	191.2	212.5	235.5						
—95	50.	61.25	72.7	84.8	97.8	111.6	126.5	142.5	159.8	178.5	198.7								
—100	52.5	64.25	76.2	88.8	102.3	116.6	132.	148.5	166.4	185.5	206.2								
—105	55.	67.25	79.7	92.8	106.8	121.6	137.5	154.5	172.8	192.5	213.7								
—110	57.5	70.25	83.2	96.8	111.3	126.6	143.	160.5											
—115	60.	73.25	86.7	100.8	115.8	131.6	148.5	166.5											
—120	62.5	76.25	90.2	104.8	120.3	136.6	154.	172.5											
—125	65.	79.25	93.7	108.8	124.8	141.6	159.5	178.5											
—130	67.5	82.25	97.2	112.8	129.3	146.6	165.	184.5											
—135	70.	85.25	100.7	116.8	133.8	151.6	170.5	190.5											
—140	72.5	88.25	104.2	120.8	138.3	156.6	176.	196.5											
—145	75.	91.25	107.7	124.8	142.8	161.6	181.5	202.5											
—150	77.5	94.25	111.2	128.8	147.3	166.6	187.	208.5											

NOTE: 1. This table gives
at any distance in meters from
the gun, the height in meters
of the center shot of the cone
below a horizontal plane passing through the gun
position. It is for use when determining clearance
over our own troops' heads in indirect overhead fire.

2. The figures in line just below distances cor-
respond to a Quadrant Elevation of —1 mil and
are used for determining height for a Quadrant
Elevation not a multiple of 5.

Example: Quadrant Elevation —63 mils; range
1300 meters. Height of trajectory $114.4 + 1.3$
meters for each mil added above 60 mils = 114.4
+ $(3 \times 1.3) = 118.3$ meters. (Depth center shot
below gun).

NOTE: 1. This table gives, at any distance in meters from the gun, the height in meters of the center shot of the cone below a horizontal plane passing through the gun position. It is for use when determining clearance over our own troops' heads in indirect overhead fire.

2. The figures in line just below distances correspond to a Quadrant Elevation of —1 mil and are used for determining height for a Quadrant Elevation not a multiple of 5.

Example: Quadrant Elevation —63 mils; range 1300 meters. Height of trajectory $114.4 + 1.3$ meters for each mil added above 60 mils = $114.4 + (3 \times 1.3) = 118.3$ meters. (Depth center shot below gun).

ALLOWANCE TABLE FOR ATMOSPHERIC CONDITIONS—Range in Meters—Corrections in Mils

ACTUAL RANGE		1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300	2400	2500	2600	2700	2800	2900	3000
Lateral Winds (For Head and Rear Winds take one-half. Add for Head Wind, Deduct for Rear Wind.)	10 mile	3.	3.4	3.8	4.2	4.6	5.	5.4	5.8	6.2	6.6	7.	7.2	7.4	7.6	7.8	8.	9.6	11.2	12.8	14.4	16.
	20 mile	6.	6.8	7.6	8.4	9.2	10.	10.8	11.6	12.4	13.2	14.	14.4	14.8	15.2	15.6	16.	19.2	22.4	25.6	28.8	32.
	30 mile	10.	11.	12.	13.	14.	15.	16.	17.	18.	19.	20.	20.8	21.6	22.4	23.2	24.	28.8	33.6	38.4	43.2	48.
Temperature Normal— F=60° C=15.56° Above Normal Deduct. Below Normal Add.	10° F. 5.55° C.	1.	1.2	1.4	1.6	1.8	2.	2.2	2.4	2.6	2.8	3.	3.2	3.4	3.6	3.8	4.	4.2	4.4	4.6	4.8	5.
	20° F. 11.11° C.	2.	2.4	2.8	3.2	3.6	4.	4.4	4.8	5.2	5.6	6.	6.4	6.8	7.2	7.6	8.	8.4	8.8	9.2	9.6	10.
	30° F. 16.67° C.	4.	4.4	4.8	5.2	5.6	6.	6.4	6.8	7.2	7.6	8.	8.4	8.8	9.2	9.6	10.	10.4	10.8	11.2	11.6	12.
	40° F. 22.22° C.	8.	8.4	8.8	9.2	9.6	10.	10.4	10.8	11.2	11.6	12.	12.4	12.8	13.2	13.6	14.	14.4	14.8	15.2	15.6	16.
	50° F. 27.27° C.	10.	10.4	10.8	11.2	11.6	12.	12.4	12.8	13.2	13.6	14.	14.4	14.8	15.2	15.6	16.	16.4	16.8	17.2	17.6	18.
Barometer Normal— 30 inches, 72.6 cm. Above Normal Add. Below Normal Deduct.	.5 inch 1.27 cm.	1.	1.2	1.4	1.6	1.8	2.	2.2	2.4	2.6	2.8	3.	3.2	3.4	3.6	3.8	4.	4.2	4.4	4.6	4.8	5.
	1.0 inch 2.54 cm.	2.	2.2	2.4	2.6	2.8	3.	3.2	3.4	3.6	3.8	4.	4.4	4.8	5.2	5.6	6.	6.4	6.8	7.2	7.6	8.
	1.5 inch 3.81 cm.	4.	4.4	4.8	5.2	5.6	6.	6.4	6.8	7.2	7.6	8.	8.4	8.8	9.2	9.6	10.	10.4	10.8	11.2	11.6	12.
	2.0 inch 5.08 cm.	6.	6.4	6.8	7.2	7.6	8.	8.8	9.6	10.4	11.2	12.	12.6	13.2	13.8	14.4	15.	15.6	16.2	16.8	17.4	18.

Example: Range 2500 meters, Angle of Departure 111.8 mils, Rear Wind 20 miles, 80° F., 31 inch Barometer.
 In 2500 meter column find under 20 mile wind 16 mils. $\frac{1}{2}$ of this deducted from 111.8 mils = 103.8 mils.
 80° F. is 20° above Normal and 8 mils are deducted from 103.8 mils, leaving 95.8 mils. 31 inch Barometer pressure is 1 inch above Normal, adding 6 mils to elevation. This brings the final elevation to 101.8 mils, corresponding to an elevation of 2400 meters.

WIND ALLOWANCES (Formulae)

Wind Direction	VE	VW
12, 6 o'clock	1	0
1, 5, 7, 11	$\frac{7}{8}$	$\frac{1}{2}$
1:30, 4:30, 7:30, 10:30	$\frac{3}{4}$	$\frac{3}{4}$
2, 4, 8, 10	$\frac{1}{2}$	$\frac{7}{8}$
3, 9 o'clock	0	1

$$\frac{R \text{ VW}}{3650} = \text{Points, Right or Left.} \quad \left\{ \begin{array}{l} R = \text{Range. (Meters)} \end{array} \right.$$

$$\frac{R \text{ VW}}{3300} = \text{Mils, Right or Left.} \quad \left\{ \begin{array}{l} \text{VW} = \text{Velocity component affecting the Windage.} \end{array} \right.$$

$$\frac{(R-400)}{190} \text{VE} = \text{Meters Correction on Sight} \quad \left\{ \begin{array}{l} \text{VE} = \text{Velocity component affecting the Elevation.} \end{array} \right.$$

Examples:

- I. Range 1000 meters; 9 o'clock, 10-mile wind.
From Table VE=0. Elevation not affected.

$$\text{VW} = 1 \times 10. \frac{R \text{ VW } 1000 \times 10}{3650 \quad 3650} = 2\frac{3}{4} \text{ points, left.}$$

or

$$\frac{R \text{ VW } 1000 \times 10}{3300 \quad 3300} = 3 \text{ mils, left.}$$

- II. Range 1000 meters; 12 o'clock, 10-mile wind.
From Table VW=0. Windage not affected.

$$\text{VE} = 1 \times 10. \frac{(R-400) \quad (1000-400)}{190 \quad 190} \times 10 = 32 \text{ meters.}$$

Sight is, therefore, set at 1032 meters.

- III. Range 1000 meters; 2 o'clock, 24-mile wind.
(R-400)

$$\text{From Table VE} = \frac{1}{2} \times 24. \frac{190}{190} \times 12 = 38 \text{ meters.}$$

$$\text{VW} = \frac{7}{8} \times 24. \frac{R \text{ VW } 1000 \times 21}{3650 \quad 3650} = 5.8 \text{ points, right.}$$

Conversion Formulae:

Points x 1000

$$\text{Mils} = \frac{\quad}{900}$$

Mils x 900

$$\text{Points} = \frac{\quad}{1000}$$

APPROXIMATE METHODS
Allowances for Atmospheric Influences
I

Less Elevation	More Elevation
Heat (80° Fahrenheit or more). Strong rear wind. Rain. Over 3000 feet above sea level. Very poor light. Firing up or down hill (may be neglected when angle of site to target does not ex- ceed 3 mils).	Cold (40° Fahrenheit or less). Strong head wind. Extreme dryness. Bright light.

Allowances in Meters of Range
II

Range	One Factor (Meters)	Two Factors (Meters)
1000 Meters		50
1500 Meters	50	100
2000 Meters	100	150

NOTES

- (a) Each of the atmospheric conditions in Table I is assumed to constitute one factor; the necessary amount of more or less elevation required to counteract a factor at each range is given in Table II.
- (b) Factors affecting elevation in opposite directions will naturally cancel each other.

Examples:

1 Factor: Range 1500 Meters: —Bright Light—Sight Setting: 1550 Meters.

2 Factors: Range 2000 Meters: —Rain—Strong Rear Wind—Sight Setting: 1850 Meters.

This table is for rough approximation only.

METRIC SYSTEM
(Compared with English.)
LONG MEASURE

	Meters	Inches	Feet	Yards	Miles
Millimeter .....	.001	.03937	.00328	.00109	—
Centimeter .....	.01	.3937	.0328	.0109	—
Decimeter .....	.1	3.937	.328	.10936	.00006
METER*	1	39.37011	3.2808	1.09361	.00062
Decameter	10	—	32.808	10.936	.00621
Hectometer	100	—	328	109.36	.06214
Kilometer	1,000	—	3280.8	1093.6	.62137
Myriameter	10,000	—	—	—	6.21372

*1 meter=1.0936143 yard.

LINEAR MEASURES

		Reciprocals
Inch	= .0254000 meters	39.370113
Foot	= .3047997 "	3.280843
Yard	= .9143992 "	1.093614
Pole	= 5.0292 "	.198839
Chain	= 20.1168 "	.0497097
Furlong	= 201.1678 "	.0049710
Mile	= 1609.3426 "	.00062137



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